LOGIC LAB

User Manual

Revision 5.0 - February 2013

AXEL

SOFTWARE SOLUTIONS FOR THE INDUSTRIAL AUTOMATION

LogicLab User Manual
Revision 5.0 - 2013-02-12
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1. OVERVIEW

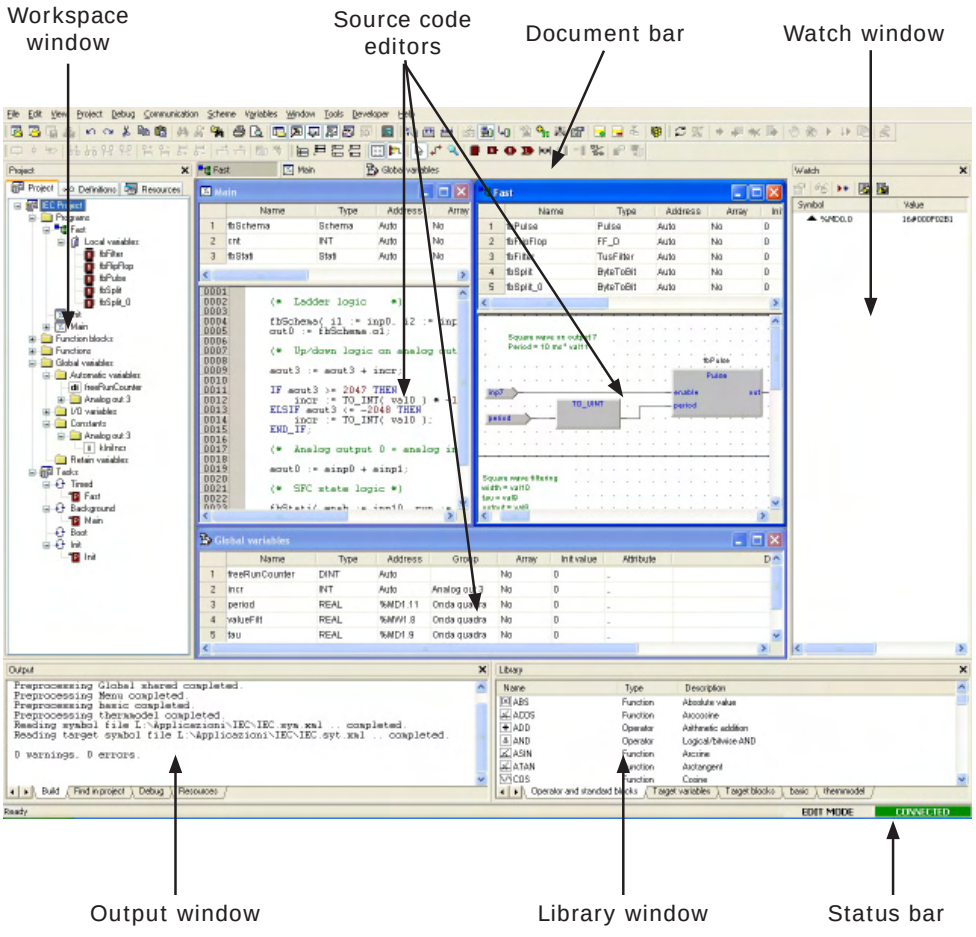
LogicLab is an IEC61131-3 Integrated Development Environment supporting the whole range of languages defined in the standard.

In order to support the user in all the activities involved in the development of an application, LogicLab includes:

- textual source code editors for the Instruction List (briefly, IL) and Structured Text (briefly, ST) programming languages (see Chapter 6.);
- graphical source code editors for the Ladder Diagram (briefly, LD), Function Block Diagram (briefly, FBD), and Sequential Function Chart (briefly, SFC) programming languages (see Chapter 6.);
- a compiler, which translates applications written according to the IEC standard directly into machine code, avoiding the need for a run-time interpreter, thus making the program execution as fast as possible (see Chapter 7.);
- a communication system which allows the download of the application to the target environment (see Chapter 8.);
- a rich set of debugging tools, ranging from an easy-to-use watch window to more powerful tools, which allows the sampling of fast changing data directly on the target environment, ensuring the information is accurate and reliable (see Chapter 9.).

1.1 THE WORKSPACE

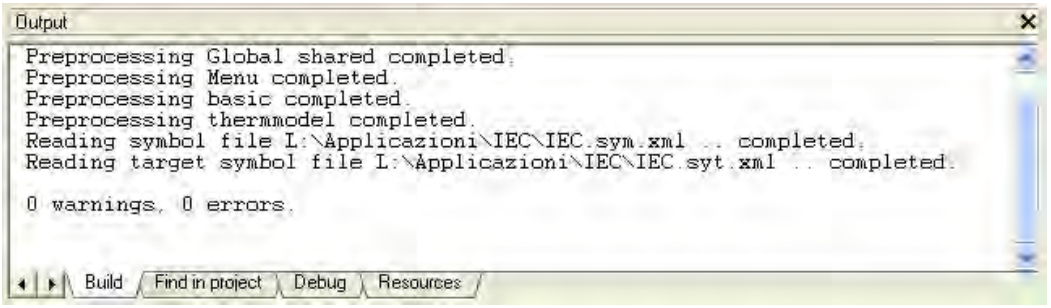
The figure below shows a view of LogicLab's workspace, including many of its more commonly used components.



The following paragraphs give an overview of these elements.

1.1.1 THE OUTPUT WINDOW

The *Output* window is the place where LogicLab prints its output messages. This window contains four tabs: *Build*, *Find in project*, *Debug*, and *Resources*.



Build

The *Build* panel displays the output of the following activities:

- opening a project;
- compiling a project;
- downloading code to a target.

Find in project

This panel shows the result of the *Find in project* activity.

Debug

The *Debug* panel displays information about advanced debugging activities (for example, breakpoints).

Resources

The *Resources* panel displays messages related to the specific target device LogicLab is interfacing with.

1.1.2 THE STATUS BAR

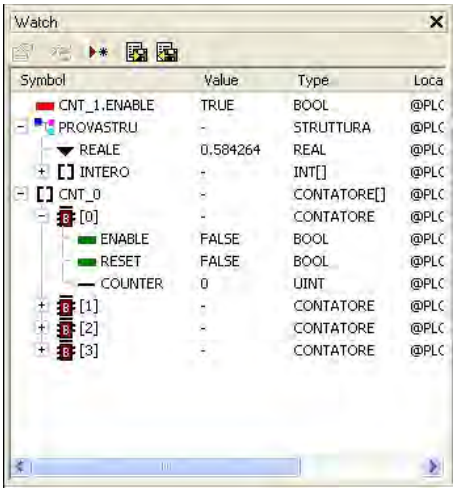
The *Status* bar displays the state of the application at its left border, and an animated control reporting the state of communication at its right border.

1.1.3 THE DOCUMENT BAR

The *Document* bar lists all the documents currently open for editing in LogicLab.

1.1.4 THE WATCH WINDOW

The *Watch* window is one of the many debugging tools supplied by LogicLab. Among the other debugging tools, it is worth mentioning the Oscilloscope (see Paragraph 9.2), triggers, and the live debug mode (see Paragraph 9.4).



1.1.5 THE LIBRARY WINDOW

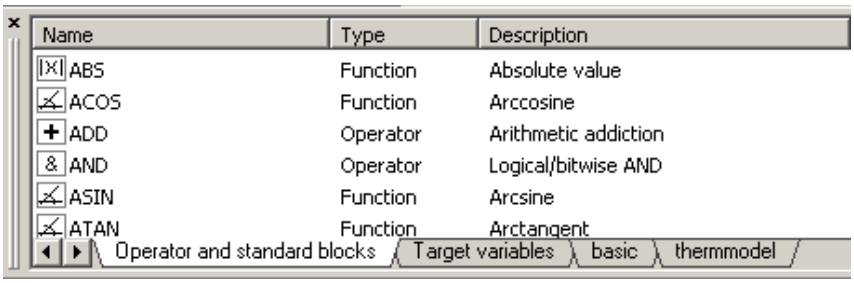
The *Library* window contains a set of different panels, which fall into the categories explained in the following paragraphs.

You can choose the display mode by clicking the right button of your mouse. In the *View list* mode, each element is represented by its name and icon. Instead, a table appears in the *View details* mode, each row of which is associated with one of the embedded elements. The latter mode also displays the *Type* (Operator/Function) and the description of each element.

If you right-click one of the elements of this panel, and you click *Object properties* from the dialog box, then a window appears with further details on the element you selected (input and output supported types, name of input and output pins, etc.).

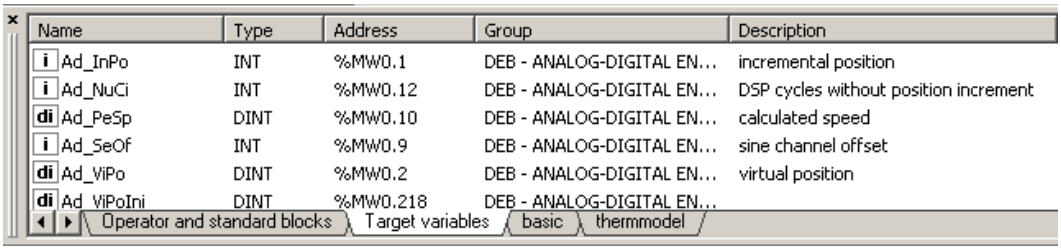
1.1.5.1 OPERATORS AND STANDARD BLOCKS

This panel lists basic language elements, such as operators and functions defined by the IEC 61131-3 standard.



1.1.5.2 TARGET VARIABLES

This panel lists all the system variables, also called target variables, which are the interface between firmware and PLC application code.

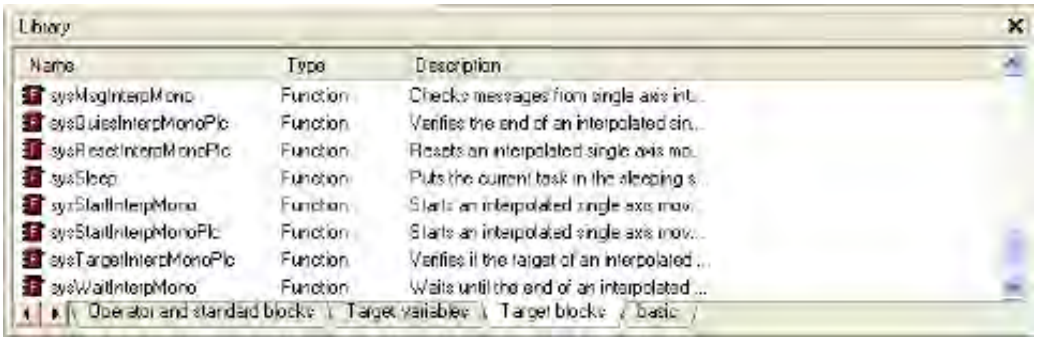


Name	Type	Address	Group	Description
Ad_InPo	INT	%MW0.1	DEB - ANALOG-DIGITAL EN...	incremental position
Ad_NuCi	INT	%MW0.12	DEB - ANALOG-DIGITAL EN...	DSP cycles without position increment
Ad_PeSp	DINT	%MW0.10	DEB - ANALOG-DIGITAL EN...	calculated speed
Ad_SeOf	INT	%MW0.9	DEB - ANALOG-DIGITAL EN...	sine channel offset
Ad_ViPo	DINT	%MW0.2	DEB - ANALOG-DIGITAL EN...	virtual position
Ad_ViPoIni	DINT	%MW0.218	DEB - ANALOG-DIGITAL EN...	

Operator and standard blocks | Target variables | basic | thermmodel

1.1.5.3 TARGET BLOCKS

This panel lists all the system functions and function blocks available on the specific target device.



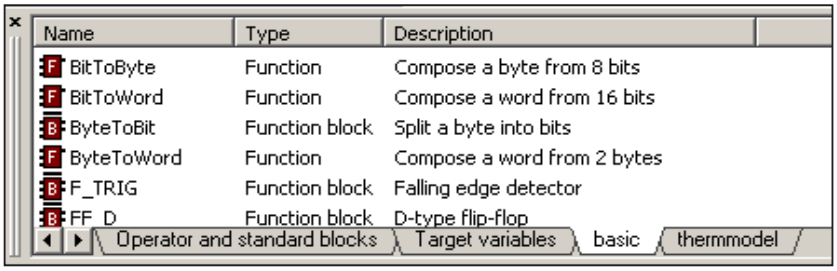
Library

Name	Type	Description
sysMsgInterpMono	Function	Checks messages from single axis int...
sysQuissInterpMonoPlc	Function	Verifies the end of an interpolated sin...
sysResetInterpMonoPlc	Function	Resets an interpolated single axis mo...
sysSleep	Function	Puts the current task in the sleeping s...
sysStartInterpMono	Function	Starts an interpolated single axis mov...
sysStartInterpMonoPlc	Function	Starts an interpolated single axis mov...
sysTargetInterpMonoPlc	Function	Verifies if the target of an interpolated ...
sysWaitInterpMono	Function	Waits until the end of an interpolated ...

Operator and standard blocks | Target variables | Target blocks | basic

1.1.5.4 INCLUDED LIBRARY PANELS

The panels described in the preceding paragraphs are usually always available in the *Library* window. However, other panels may be added to this window, one for each library included in the current LogicLab project. For example, the picture above was taken from a LogicLab project having two included libraries, *basic.pll* and *thermmodel.pll* (see also Paragraph 4.7).

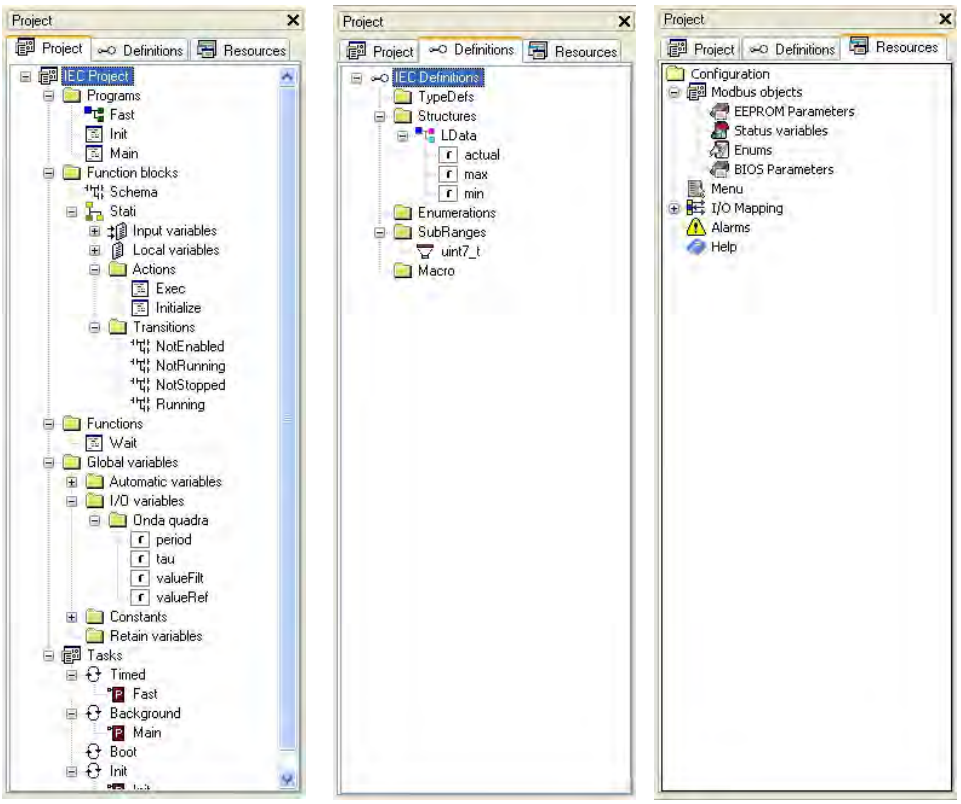


Name	Type	Description
BitToByte	Function	Compose a byte from 8 bits
BitToWord	Function	Compose a word from 16 bits
ByteToBit	Function block	Split a byte into bits
ByteToWord	Function	Compose a word from 2 bytes
F_TRIG	Function block	Falling edge detector
FF_D	Function block	D-type flip-flop

Operator and standard blocks | Target variables | basic | thermmodel

1.1.6 THE WORKSPACE WINDOW

The *Workspace* window consists of three distinct panels, as shown in the following picture.



1.1.6.1 PROJECT

The *Project* panel contains a set of folders:

- *Program*, *Function blocks*, *Functions*: each folder contains Program Organization Units (briefly, POUs - see Paragraph 5.1) of the type specified by the folder name.
- *Global variables*: it is further divided in *Variables*, *I/O Variables*, *Constants* and *Retain variables*. Each folder contains global variables of the type specified by the folder name (see Paragraph 5.2).
- *Tasks*: this item lists the system tasks and the programs assigned to each task (see Paragraph 5.3).

1.1.6.2 DEFINITIONS

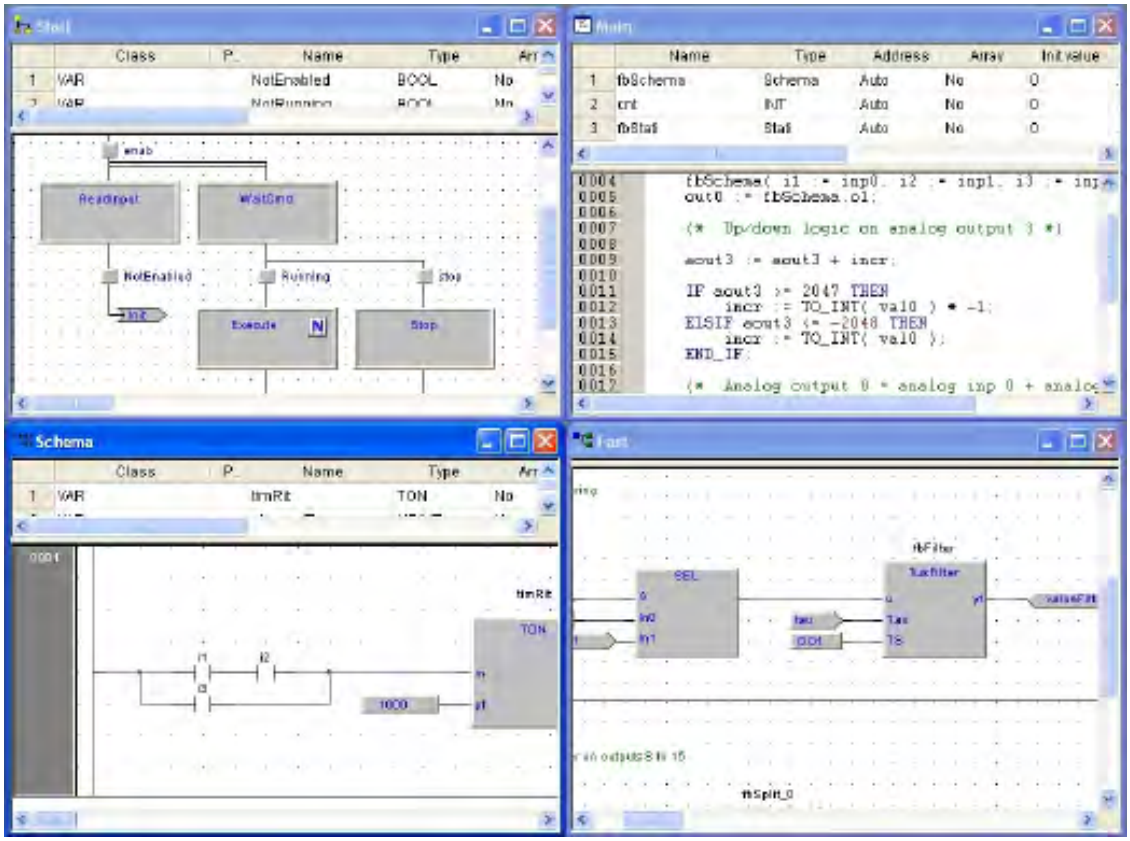
The *Definitions* panel contains the definitions of all user-defined data types, such as structures or enumerated types.

1.1.6.3 RESOURCES

The contents of the *Resources* panel depends on the target device LogicLab is interfacing with: it may include configuration elements, schemas, wizards, and so on.

1.1.7 THE SOURCE CODE EDITORS

The LogicLab programming environment includes a set of editors to manage, edit, and print source files written in any of the 5 programming languages defined by the IEC 61131-3 standard (see Chapter 6.).



The definition of both global and local variables is supported by specific spreadsheet-like editors.

	Name	Type	Address	Group	Array	Initvalue	Attribute	Description
1	freeRunCounter	DINT	Auto		No	0		
2	incr	INT	Auto	Analog out 3	No	0	..	
3	period	REAL	%MD1.11	Onda quadra	No	0	..	
4	valueFlt	REAL	%MW1.8	Onda quadra	No	0	..	
5	tau	REAL	%MD1.9	Onda quadra	No	0	..	
6	valueRef	REAL	%MD1.10	Onda quadra	No	0	..	
7	khIncr	INT	Auto	Analog out 3	No	50	CONSTANT	

2. QUICK START

This chapter is a step-by-step tutorial that introduces you to the use of the LogicLab development environment.

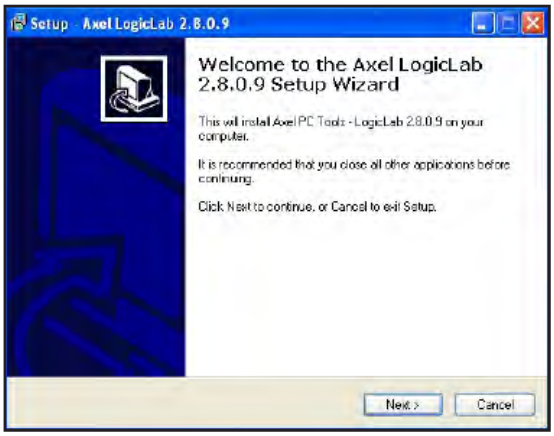
You will be guided through all the tasks you need to accomplish in order to run and monitor a simple PLC application.

The examples in this chapter refer to a virtual target, *VPLC1*, which is installed along with LogicLab during the setup procedure.

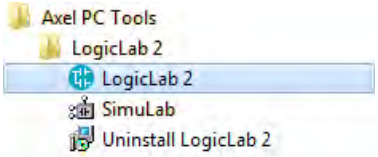
2.1 SETUP PROCEDURE

In order to install LogicLab, follow this simple procedure:

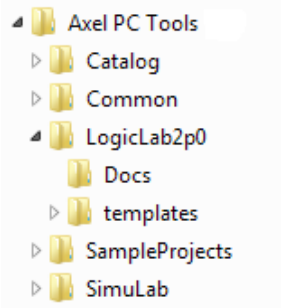
1) Close all the applications running on the system.
2) Run LogicLab's setup executable file and follow the instructions shown in the setup wizard.


Setup - Axel LogicLab 2.8.0.9
Welcome to the Axel LogicLab 2.8.0.9 Setup Wizard
This will install Axel PC Tools - LogicLab 2.8.0.9 on your computer.
It is recommended that you close all other applications before continuing.
Click Next to continue, or Cancel to exit Setup.
Next >
Cancel

The setup procedure adds the following *Start* menu.



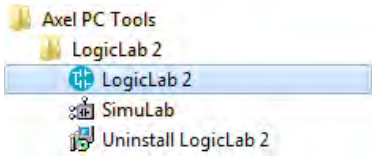
The LogicLab's folder in the file system has the following structure.



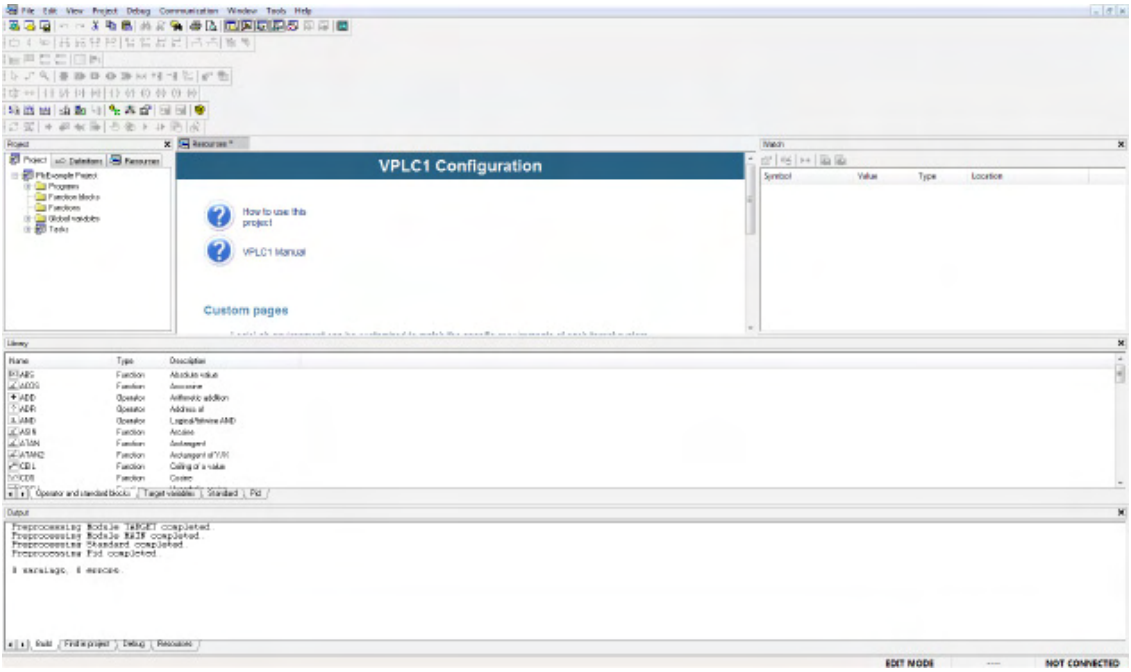
2.2 USING THE IDE

The following steps show you how to create, run and debug a simple LogicLab PLC program. The program will be written in the ST language and will be executed directly on your machine. A virtual target, *VPLC1*, has been installed by the setup procedure. *VPLC1* emulates a simple programmable controller provided with digital and analog I/O.

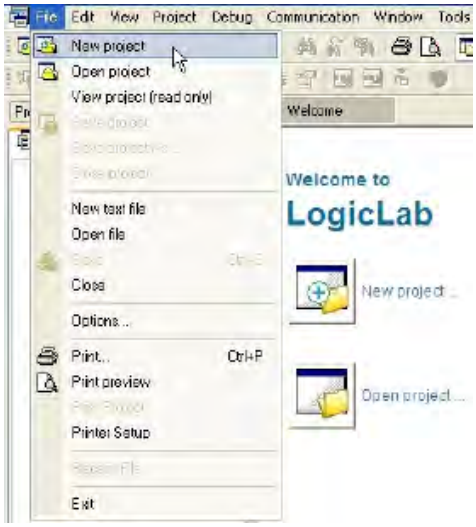
1) Launch LogicLab from the *Start* menu.



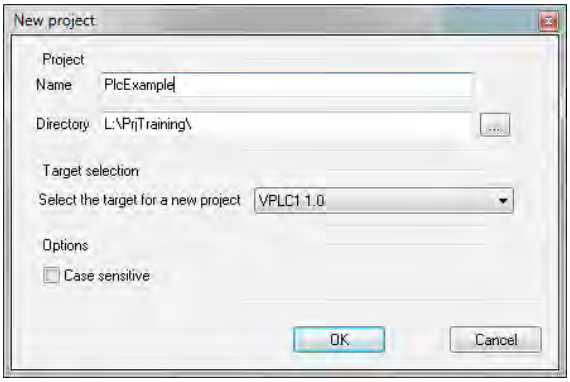
2) When LogicLab is started for the first time, not all windows and toolbars are shown. You can customize LogicLab's workspace through the *View* menu.



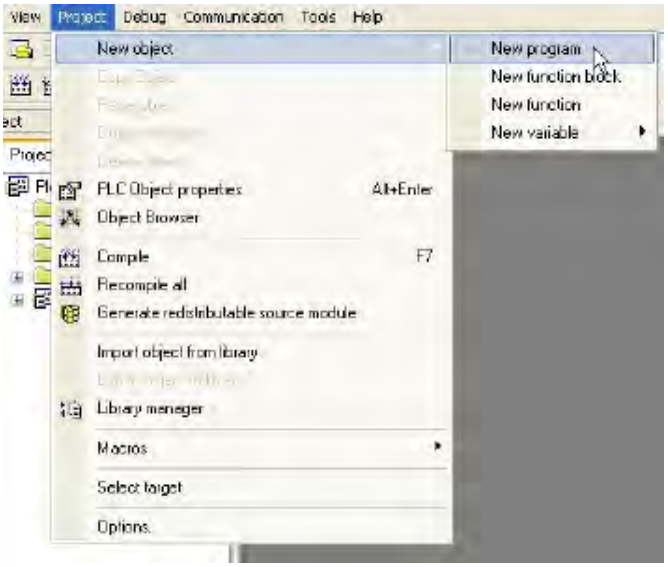
3) In order to create a new project, select the item *New project* from the menu *File*.



4) Insert the new project name (for example, *PlcExample*) and choose the destination folder, then press *OK*. *VPLC1* virtual target has been selected for this project. LogicLab's workspace looks now like in the picture shown at step 2 (that is, all operators and target variables are shown, preprocessing status log has been printed in the output window).

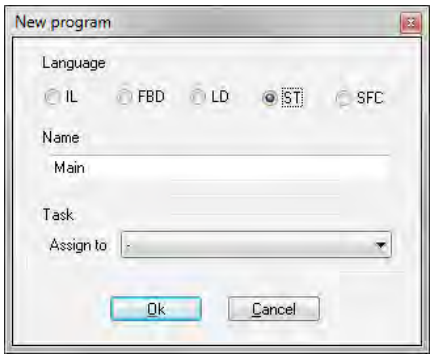


5) To add a new empty program to the project, select *New program* from the menu *Project > New object*.



Choose the ST language, insert the new program name (for example, *Main*), and press *OK*.

It is also possible to assign here the program to one of the available tasks.



LogicLab shows now the editor window of the *Main program* object. On the top of the window there is the local variables editor. The variables editor allows to add, remove, copy and paste variable definitions.

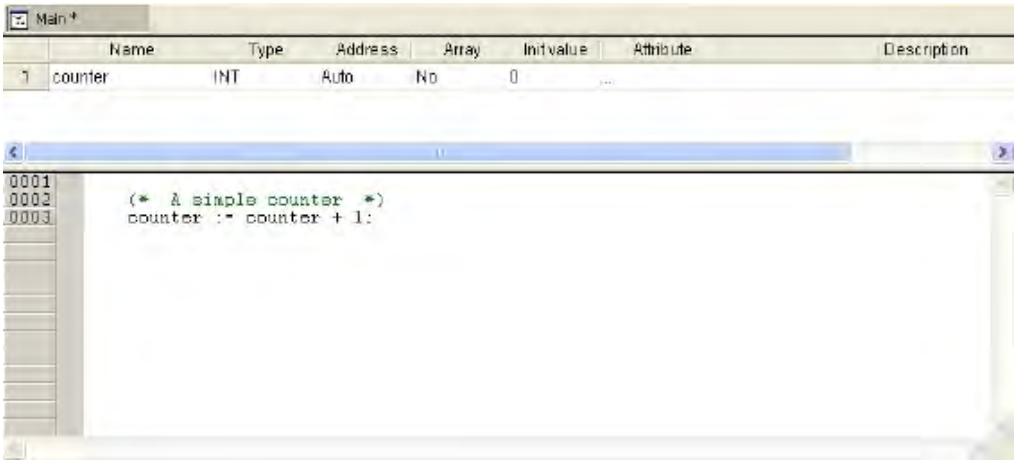
The textual source code editor is placed in the bottom part of the window.

6) Insert a new local variable by pressing the *Insert record* button in the *Project* toolbar. Alternatively, you can use the *Insert* option of the *Variables* menu.

7) Edit the name (for example, *Counter*) and the type of the variable. A double-click in the type field opens the type selection dialog.

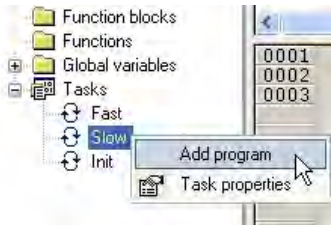
   Choose the INT data type.

8) Implement a simple counter in ST language, as shown below.

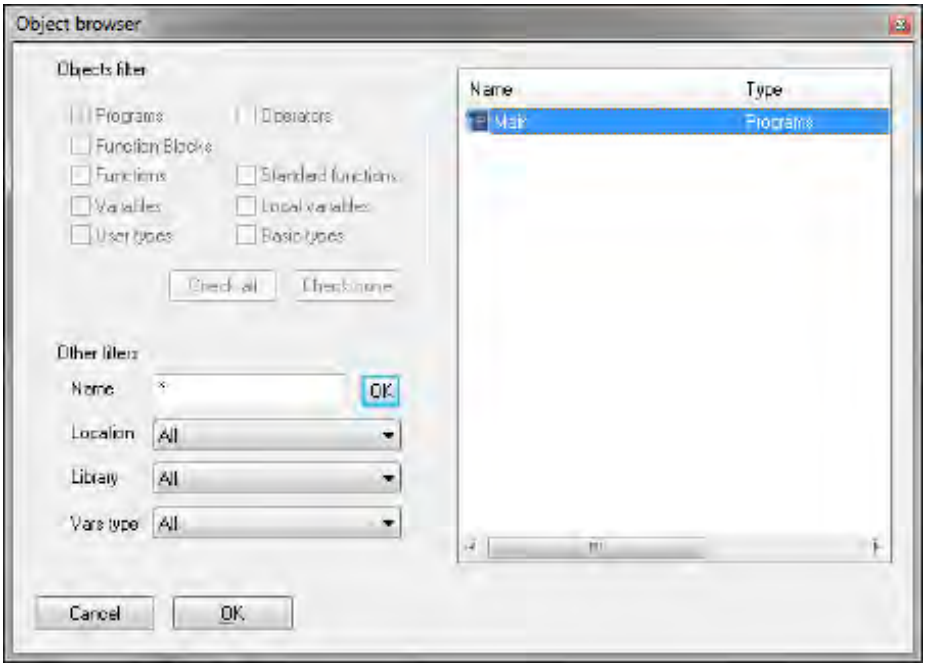


9) In order to be executed, the program *Main* has to be assigned to a task.

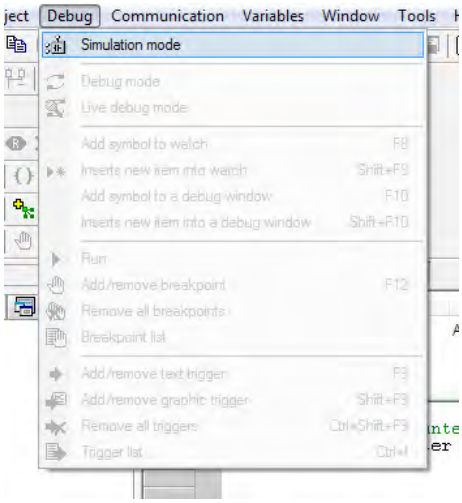
   In the *Workspace* window, right-click on the *Slow* task and select the *Add program* option. The *Object browser* window pops up.



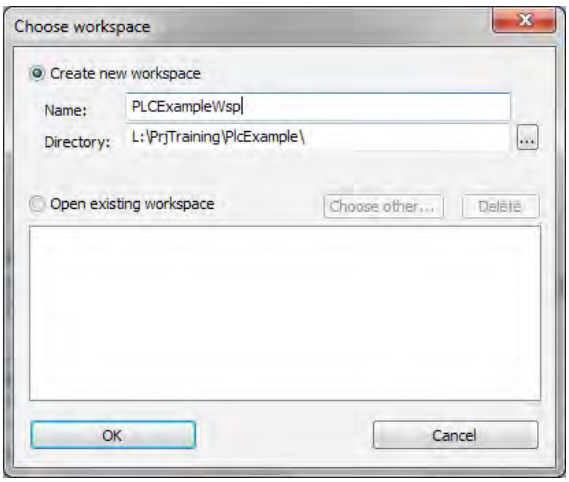
10) Select the *Main* program and click *OK*. The picture below shows the *Workspace* window after the successful completion of the operation.



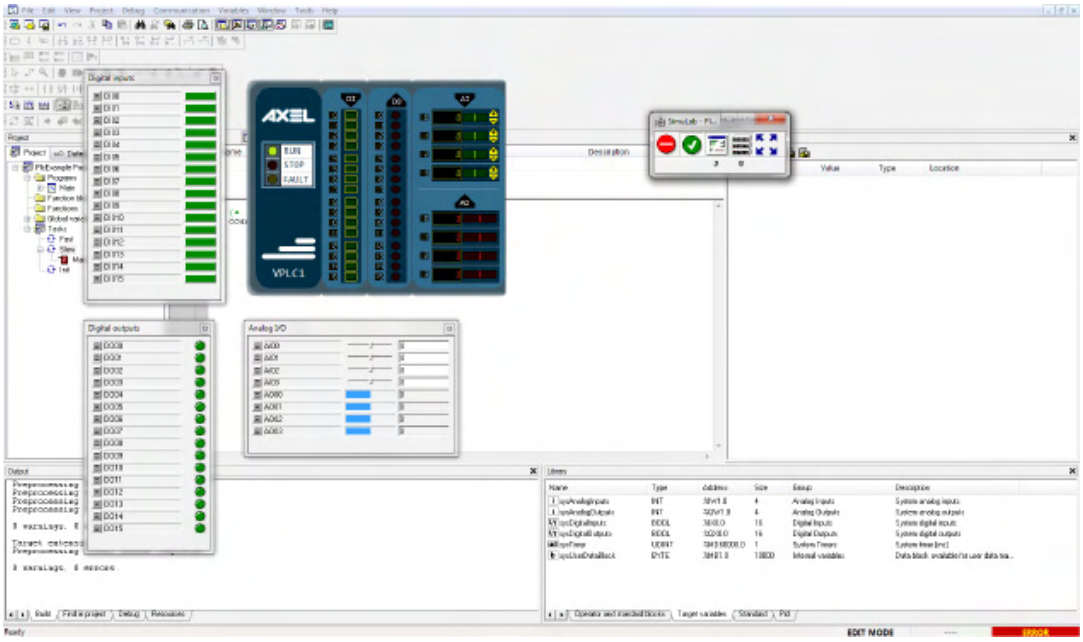
11) Select *Simulation mode* from *Debug* menu.



Name your *VPLC1* workspace as PLCExampleWsp, then press *OK*.



12) *VPLC1* is a software which emulates a simple programmer controller provided with digital and analog I/O. It is possible to interact with simulator as explained in Simu-Lab manual or briefly in *Resources* tab.



The status of the *VPLC1* I/O is available in LogicLab as the *Target variables* listed in the *Library* window.

13) With LogicLab connect to *VPLC1* through the apposite button on the toolbar.

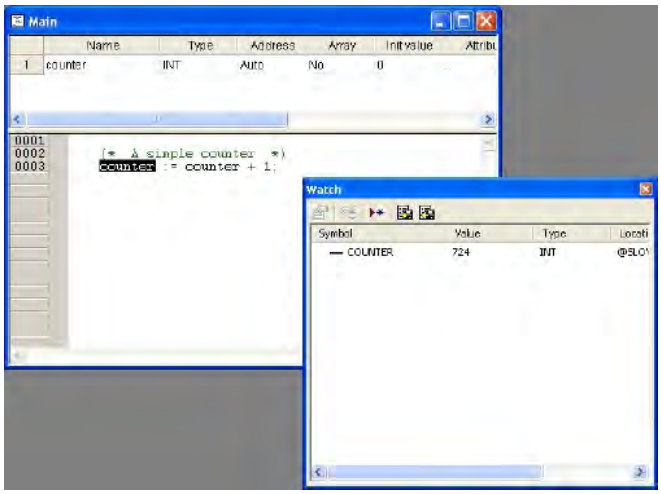
14) Press *F7* (or select the menu option *Project* - *Compile*) to compile the application. Verify that the compilation ends with *0 warning* - *0 errors*, otherwise correct the errors and compile again.

15) Download the code by means of the appropriate toolbar command.

PLC is now running on *VPLC1*. You can see the LogicLab bottom bar indicating *Source ok* - *Connected*.

16) Open the *Watch* window through the *View* menu, then select the variable in the text editor with a double-click and drag and drop it into the *Watch* window.

The *Watch* window should display the value of the *Counter* variable which should increment continuously.



You are at the end of this very simple but complete (edit-compile-download-debug) working session with LogicLab.

Further steps you should take in order to acquire a deeper knowledge of the tool include the use of the other languages, function & function blocks, global variables, libraries, real time debugging and so on. Refer to the following sections of this manual to obtain the necessary information.

2.3 A MORE COMPLEX EXAMPLE

In the *SampleProjects\Sample* subdirectory of your LogicLab installation you can find a more complex *VPLC1* example, which offers an overview of IEC 61131-3 languages.

To open the project use the *File - Open project* menu option and open *VPLC1Sample.ppjs* or select it from *Example projects* list in the welcome page.

3. USING THE ENVIRONMENT

This chapter shows you how to deal with the many UI elements LogicLab is composed of, in order to let you set up the IDE in the way which best suits to your specific development process.

3.1 LAYOUT CUSTOMIZATION

The layout of LogicLab's workspace can be freely customized in order to suit your needs.

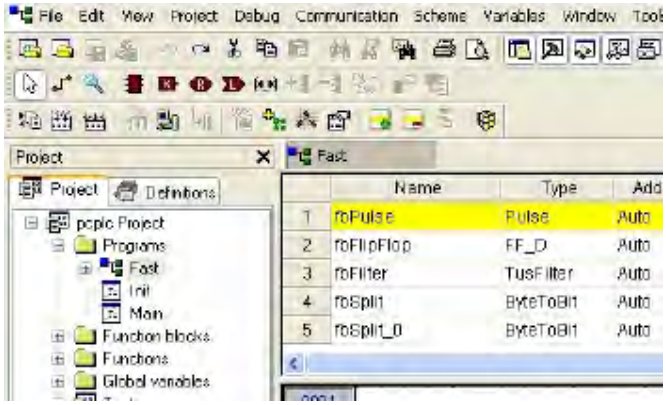
LogicLab takes care to save the layout configuration on application exit, in order to persist your preferences between different working sessions.

3.2 TOOLBARS

3.2.1 SHOWING/HIDING TOOLBARS

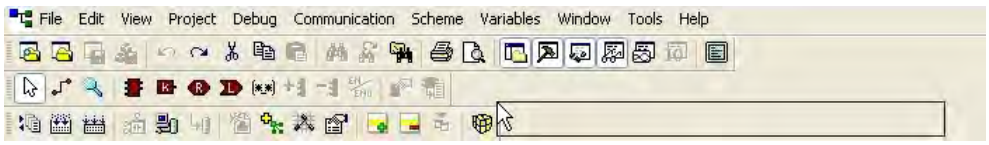
In details, in order to show (or hide) a toolbar, open the *View>Toolbars* menu and select the desired toolbar (for example, the *Function Block Diagram* bar).

The toolbar is then shown (hidden).

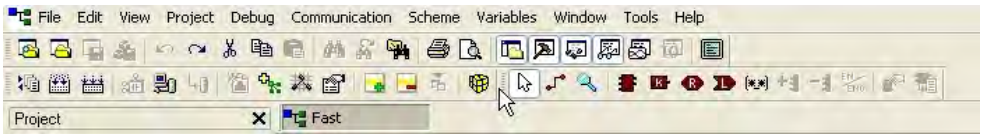


3.2.2 MOVING TOOLBARS

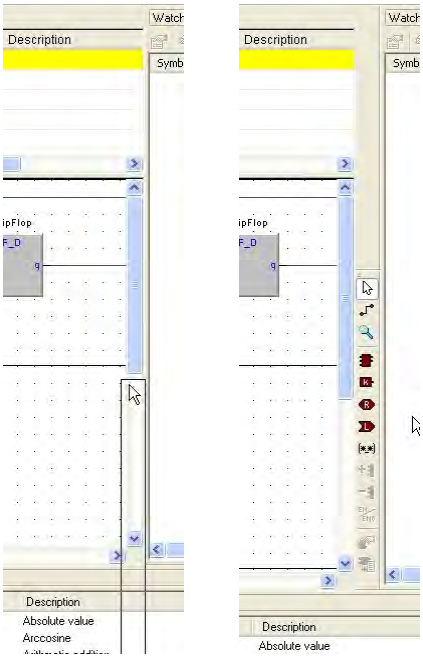
You can move a toolbar by clicking on its left border and then dragging and dropping it to the destination.



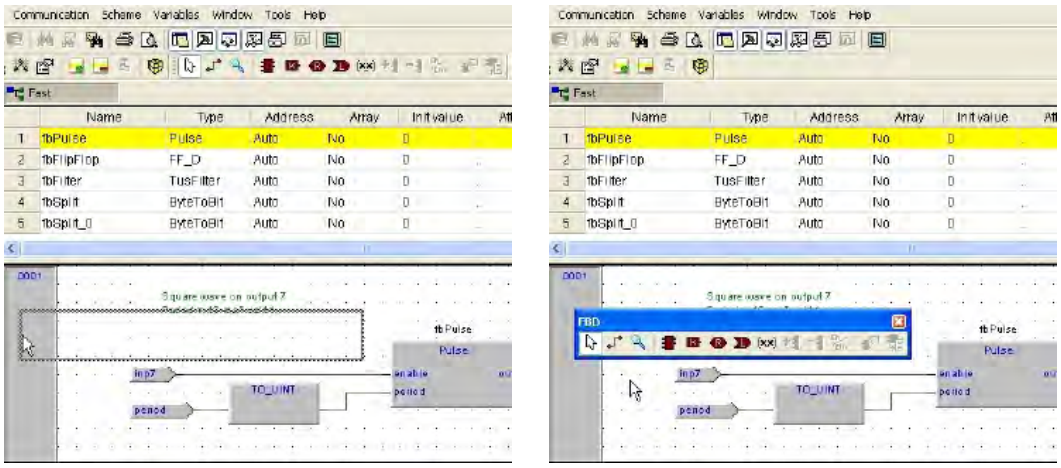
The toolbar shows up in the new position.



You can change the shape of the toolbar, from horizontal to vertical, either by pressing the *Shift* key or by moving the toolbar next to the vertical border of any window.



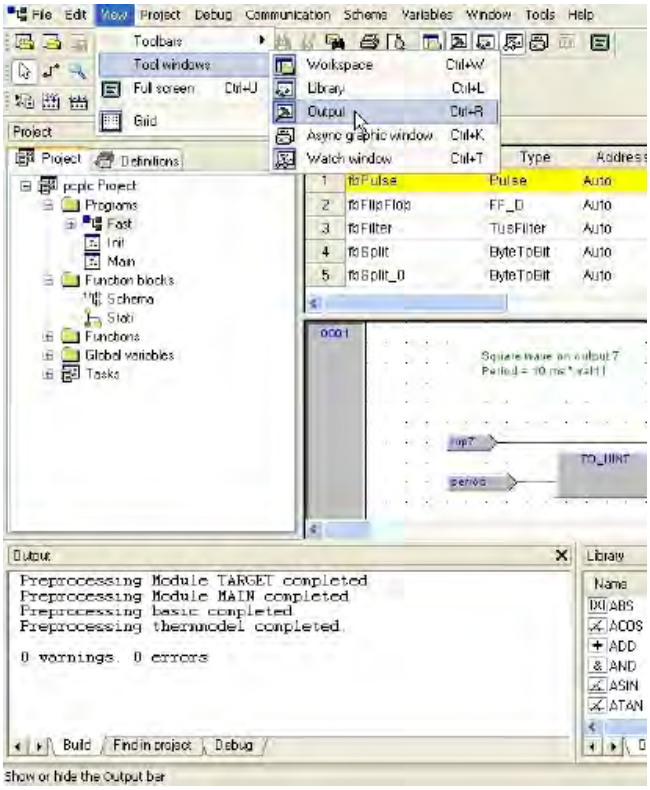
You can also make the toolbar float, either by pressing the *CTRL* key or by moving the toolbar away from any window border.


Communication Scheme Variables Window Tools Help
Fast
Name Type Address Array Init value
1 tbPulse Pulse Auto No 0
2 tbFlipFlop FF_D Auto No 0
3 tbFilter TusFilter Auto No 0
4 tbSplit ByteToBit Auto No 0
5 tbSplit_0 ByteToBit Auto No 0
FBD

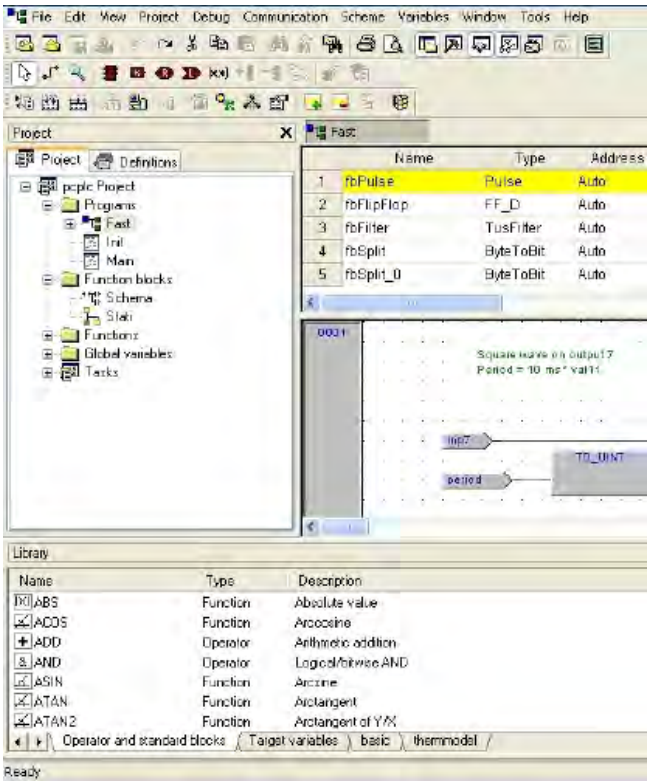
3.3 DOCKING WINDOWS

3.3.1 SHOWING/HIDING TOOL WINDOWS

The *View>Tool* windows menu allows you to show (or hide) a tool window (for example, the *Output* window).

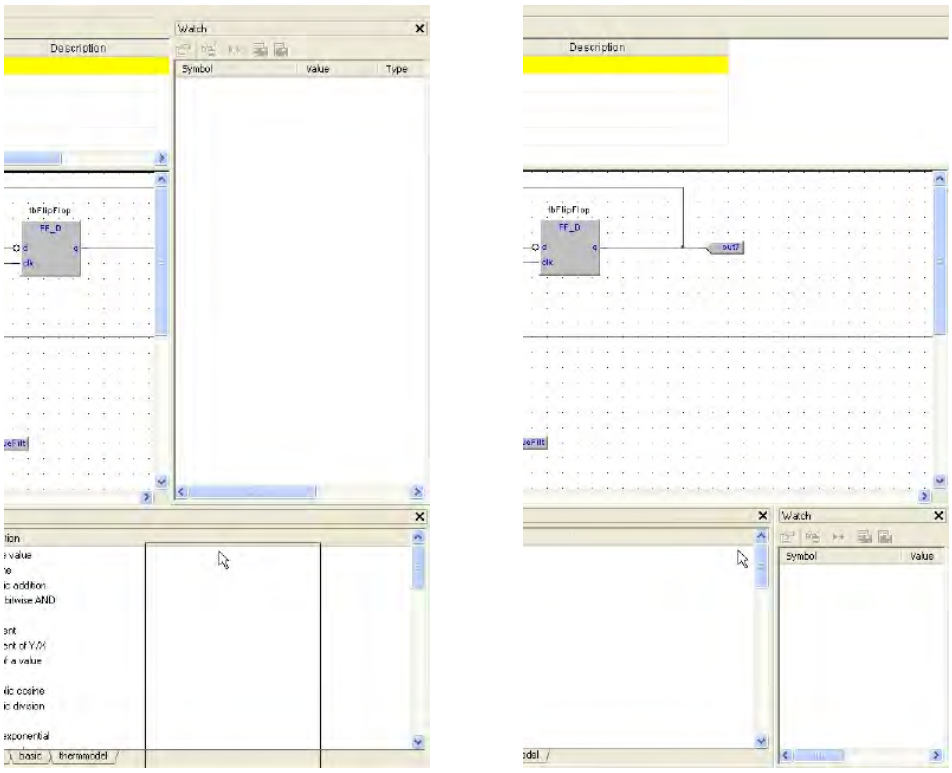


The tool window is then shown (hidden).

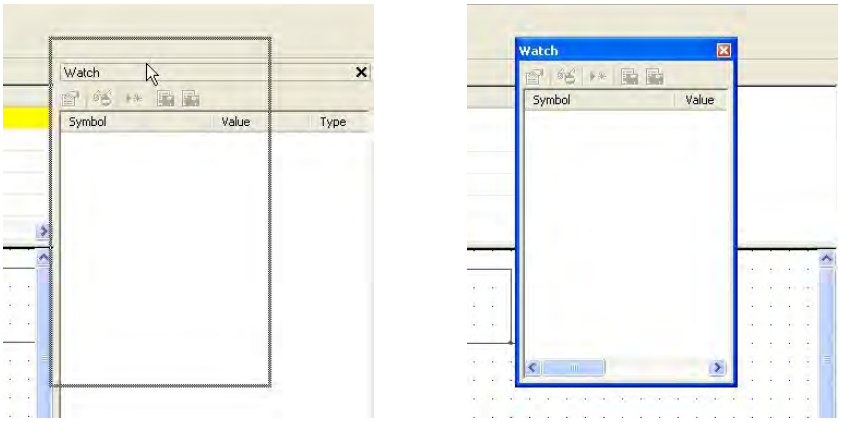


3.3.2 MOVING TOOL WINDOWS

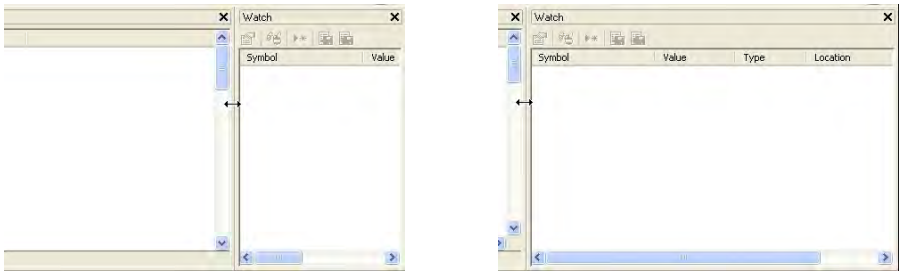
In order to move a tool window, click on its name (at the top of the window) and then drag and drop it to the destination.



You can make the tool window float, by double-clicking on its name, or by pressing the *CTRL* key, or by moving the tool window away from the main window borders.



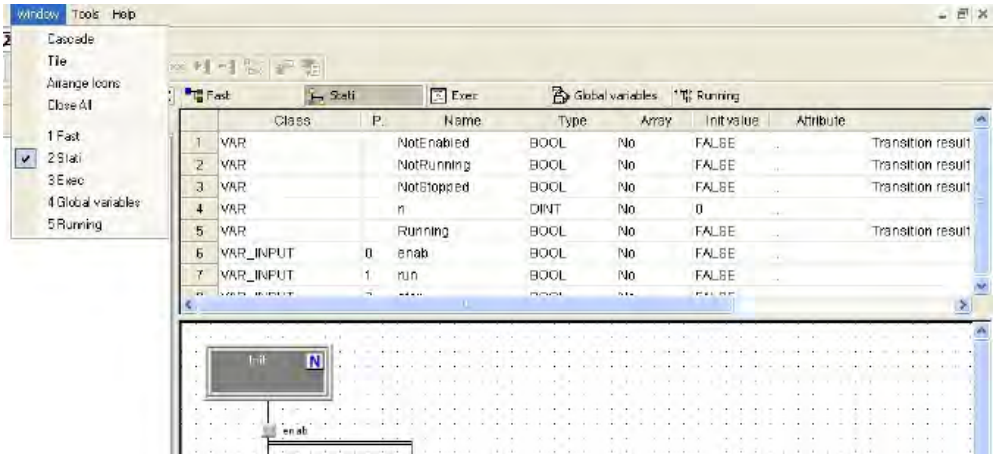
A tool window can be resized by clicking-and-dragging on its border until the desired size is reached.



3.4 WORKING WITH WINDOWS

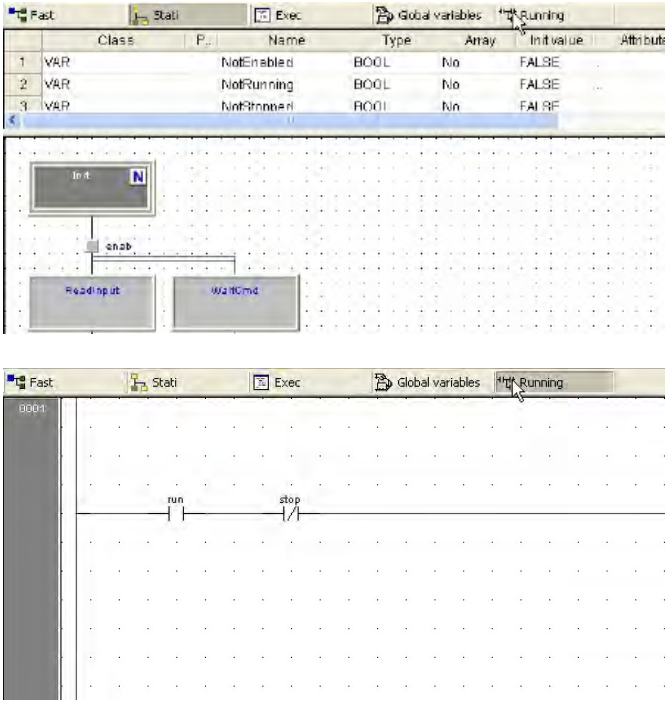
LogicLab allows to open many source code editors so that the workspace could get rather messy.

You can easily navigate between these windows through the *Document* bar and the *Window* menu.



3.4.1 THE DOCUMENT BAR

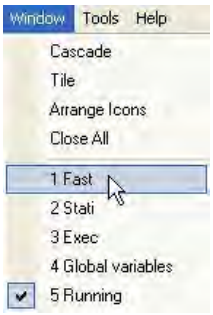
The *Document* bar allows to switch between all the currently open editors, simply by clicking on the corresponding name.



You can show or hide the *Document* bar with the menu option of the same name in the menu *View>Toolbars*.

3.4.2 THE WINDOW MENU

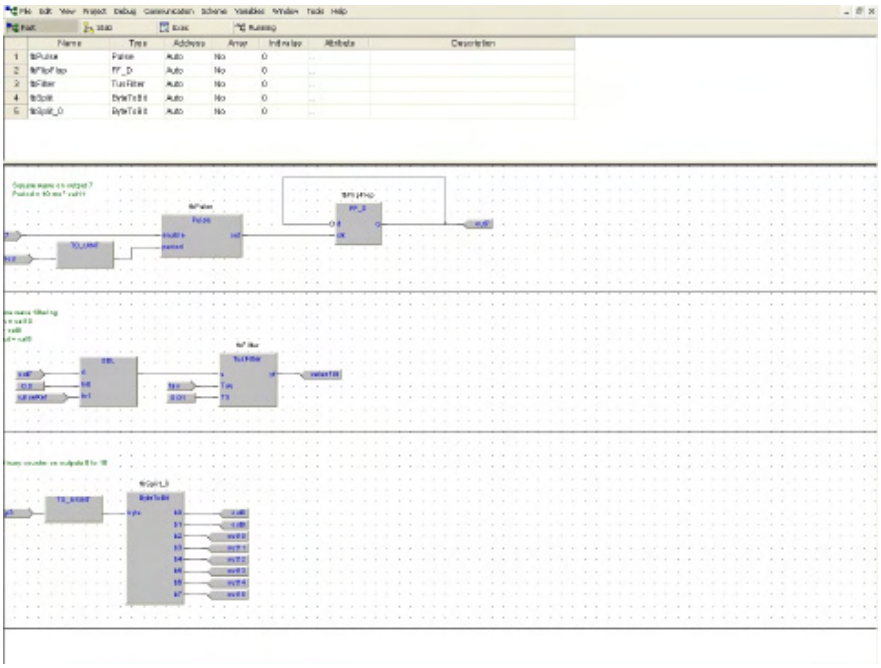
The *Window* menu is an alternative to the *Document* bar: it lists all the currently open editors and allows to switch between them.



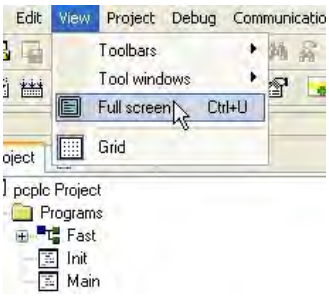
Moreover, this menu supplies a few commands to automate some basic tasks, such as closing all windows.

3.5 FULL SCREEN MODE

In order to ease the coding of your application, you may want to switch on the full screen mode. In full screen mode, the source code editor extends to the whole working area, making easier the job of editing the code, notably when graphical programming languages (that is, LD. FBD, and SFC) are involved.



You can switch on and off the full screen mode with the *Full screen* option of the menu *View* or with the corresponding command of the *Main* toolbar.



3.6 ENVIRONMENT OPTIONS

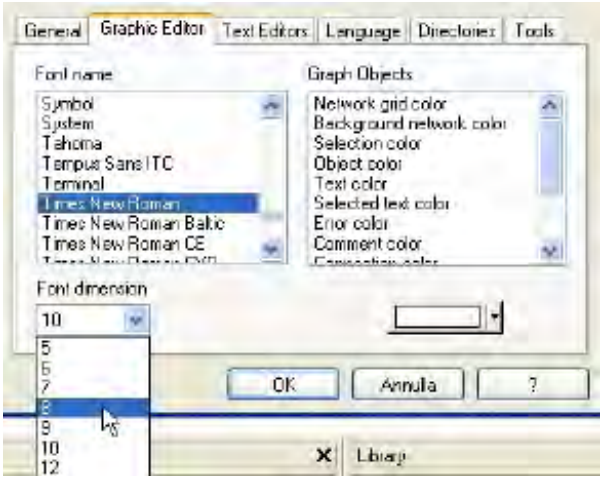
If you click *Options*... in the *File* menu, a multi-tab dialog box appears and lets you customize some options of LogicLab.

General

Autosave: if the *Enable Autosave* box is checked, LogicLab periodically saves the whole project. You can specify the period of execution of this task by entering the number of minutes between two automatic savings in the *Autosave interval* text box.

Graphic Editor

This panel lets you edit the properties of the LD, FBD, and SFC source code editors.



Text Editors

Language

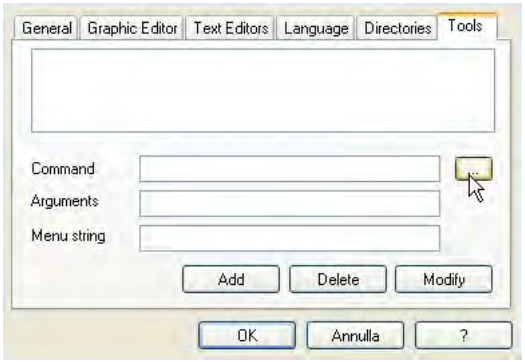
You can change the language of the environment by selecting a new one from the list shown in this panel.

After selecting the new language, press the *Select* button and confirm by clicking *OK*. This change will be effective only the next time you start LogicLab.

Tools

You can add up to 16 commands to the *Tools* menu. These commands can be associated with any program that will run on your operating system. You can also specify arguments for any command that you add to the *Tools* menu. The following procedure shows you how to add a tool to the *Tools* menu.

1) Type the full path of the executable file of the tool in the *Command* text box. Otherwise, you can specify the filename by selecting it from Windows Explorer, which you open by clicking the *Browse* button.



2) In the *Arguments* text box, type the arguments - if any - to be passed to the executable command mentioned at step 1. They must be separated by a space.

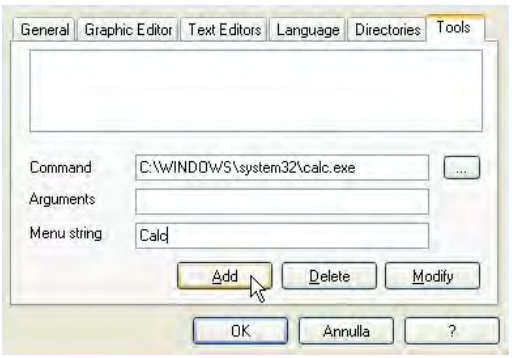
3) Enter in *Menu string* the name you want to give to the tool you are adding. This is the string that will be displayed in the *Tools* menu.

4) Press *Add* to effectively insert the new command into the suitable menu.

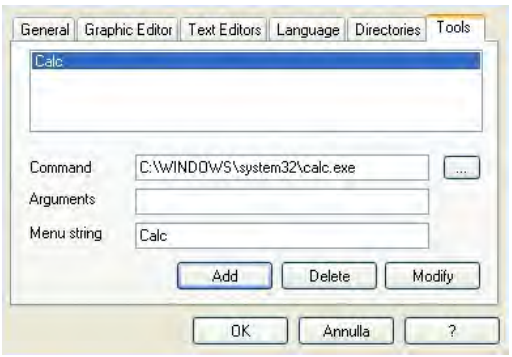
5) Press *OK* to confirm, or *Cancel* to quit.

For example, let us assume that you want to add *Windows calculator* to the *Tools* menu:

- Fill the fields of the dialog box as displayed.



- Press *Add*. The name you gave to the new tool is now displayed in the list box at the top of the panel.



And in the *Tools* menu as well.

4. MANAGING PROJECTS

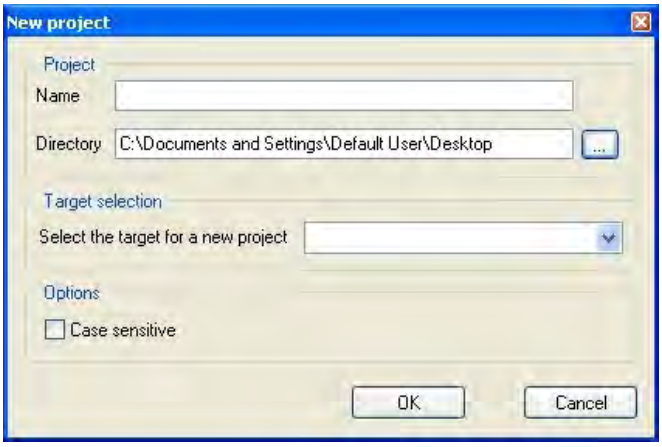
This chapter focuses on LogicLab projects.

A project corresponds to a PLC application and includes all the required elements to run that application on the target device, including its source code, links to libraries, information about the target device and so on.

The following paragraphs explain how to properly work with projects and their elements.

4.1 CREATING A NEW PROJECT

To start a new project, click *New project* in the *File* menu of the LogicLab main window. The same command is available in the *Main* toolbar and, if no project is open, in LogicLab's welcome page. This causes the following dialog box to appear.



You are required to enter the name of the new project in the *Name* control. The string you enter will also be the name of the folder which will contain all the files making up the LogicLab project. The pathname in the *Directory* control indicates the default location of this folder.

Target selection allows you to specify the target device which will run the project.

Finally, you can make the project case-sensitive by activating the related option. Note that, by default, this option is not active, in compliance with IEC 61131-3 standard: when you choose to create a case-sensitive project, it will not be standard-compliant.

When you confirm your decision to create a new project and the whole required information has been provided, LogicLab completes the operation, creating the project directory and all project files; then, the project is opened.

The list of devices from which you can select the target for the project you are creating depends on the contents of the catalog of target devices available to LogicLab.

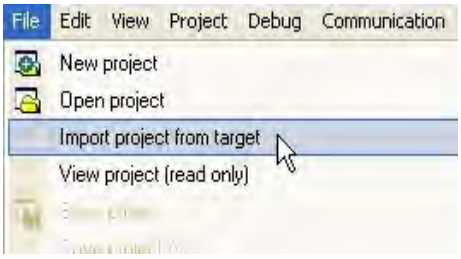
When the desired target is missing, either you have run the wrong setup executable or you have to run a separate setup which is responsible to update the catalog to include the target device. In both cases, you should contact your hardware supplier for support.

4.2 UPLOADING THE PROJECT FROM THE TARGET DEVICE

Depending on the target device you are interfacing with, you may be able to upload a working LogicLab project from the target itself.

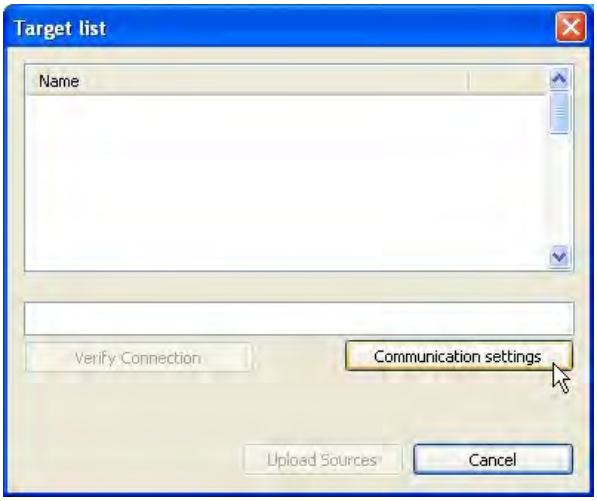
In order to upload the project from the target device, follow the procedure below:

1) Select the item *Import project from target* in the menu *File*.

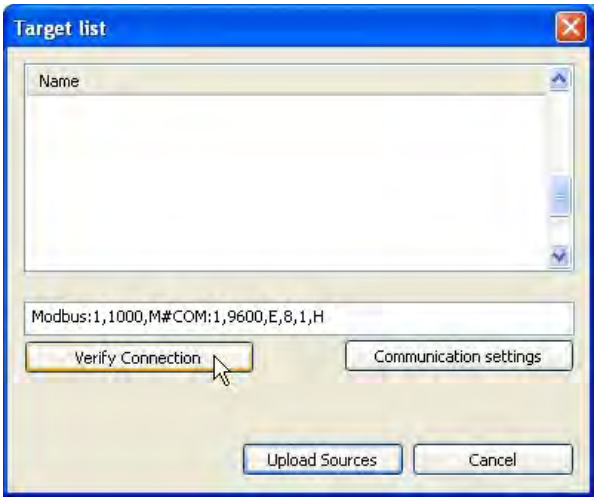


2) Select the target device you are connecting to, from the list shown in the *Target list* window.

3) Set up the communication (refer to Setting up the communication section for details).

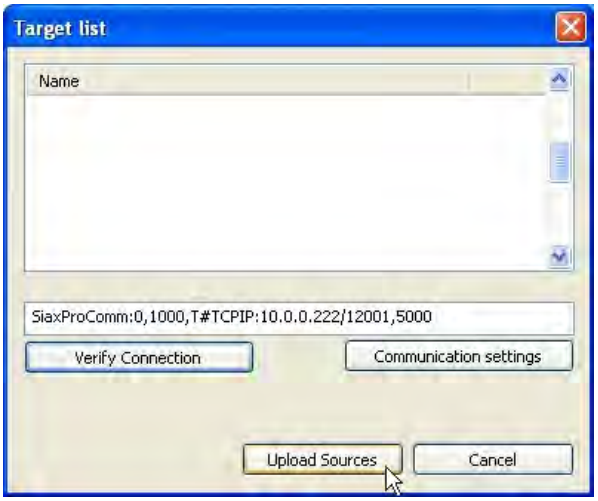


4) You may optionally test the connection with the target device.



LogicLab tries to open the connection and reports the test result.

5) Confirm the operation.



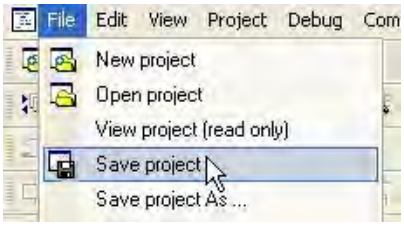
When the application upload completes successfully, the project is open for editing.

4.3 SAVING THE PROJECT

4.3.1 PERSISTING CHANGES TO THE PROJECT

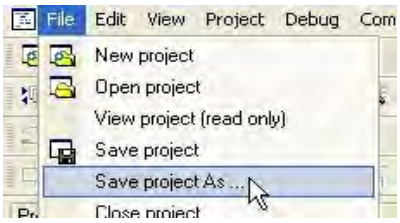
When you make any change to the project (for example, you add a new Program Organization Unit) you are required to save the project in order to persist that change.

To save the project, you can select the corresponding item of the menu *File* or the *Main* toolbar.



4.3.2 SAVING TO AN ALTERNATIVE LOCATION

When you do not want to (or cannot - for example, because the file is read-only) overwrite the project file, you may save the modified version of the project to an alternative location, by selecting *Save project as*... from the *File* menu.



LogicLab asks you to select the new destination (which must be an empty directory), then saves a copy of the project to that location and opens this new project file for editing.

4.4 MANAGING EXISTING PROJECTS

4.4.1 OPENING AN EXISTING LOGICLAB PROJECT

To open an existing project, click *Open project* in the *File* menu of LogicLab's main window, or in the *Main* toolbar, or in the *Welcome page* (when no project is open). This causes a dialog box to appear, which lets you load the directory containing the project and select the relative project file.

4.4.2 EDITING THE PROJECT

In order to modify an element of a project, you need first to open that element by double-clicking its name, which you can find by browsing the tree structure of the project tab of the *Workspace* bar.

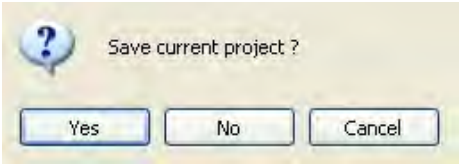
By double-clicking the name of the object you want to modify, you open an editor consistent with the object type: for example, when you double-click the name of a project POU, the appropriate source code editor is shown; if you double-click the name of a global variable, the variable editor is shown.

Note that LogicLab prevents you from applying changes to elements of a project, when at least one of the following conditions holds:

- You cannot modify any object of the project if you are in debug mode.
- You cannot edit an object of an included library, whereas you can modify an object that you imported from a library.
- The project is opened in read-only mode (view project).

4.4.3 CLOSING THE PROJECT

You can terminate the working session either by explicitly closing the project or by exiting LogicLab. In both cases, when there are changes not yet persisted to file, LogicLab asks you to choose between saving and discarding them.



To close the project, select the item *Close project* from the *File* menu; LogicLab shows the *Welcome page*, so that you can rapidly start a new working session.

4.5 DISTRIBUTING PROJECTS

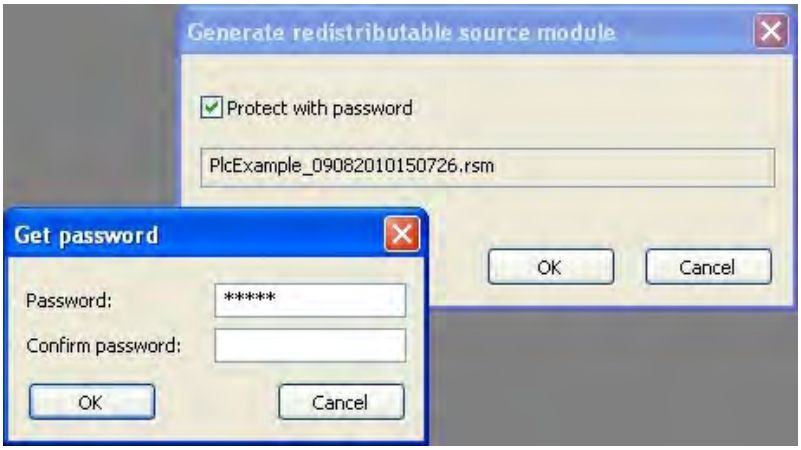
When you need to share a project with another developer you can send him/her either a copy of the project file(s) or a redistributable source module (RSM) generated by LogicLab.

In the former case, the number of files you have to share depends on the format of the project file:

- PLC single project file (*.ppjs* file extension): the project file itself contains the whole information needed to run the application (assuming the receiving developer has an appropriate target device available) including all source code modules, so that you need to share only the *.ppjs* file.
- PLC multiple project file (*.ppjx* or *.ppj* file extension): the project file contains only the links to the source code modules composing the project, which are stored as single files in the project directory. You need to share the whole directory.

Alternatively, you can generate a redistributable source module (RSM) with the corresponding item of the *Project* menu or toolbar.

LogicLab notifies you of the name of the RSM file and lets you choose whether to protect the file with a password or not. If you choose to protect the file, LogicLab asks you to insert the password.

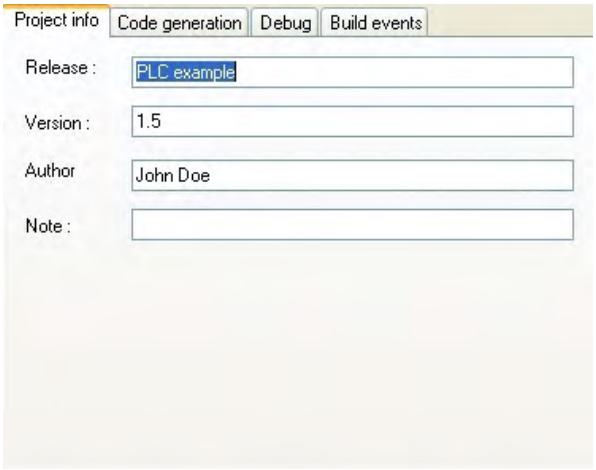


The advantages of the RSM file format are:

- the source code is encoded in binary format, thus it cannot be read by third parties which do not use LogicLab, making a transfer over the Internet more secure;
- it can be protected with a password, which will be required by LogicLab on file opening;
- being a binary file, its size is reduced.

4.6 PROJECT OPTIONS

You can edit some basic properties of the project, such as application name and version, in the window which pops up after you select the item *Options*... in the *Project* menu.

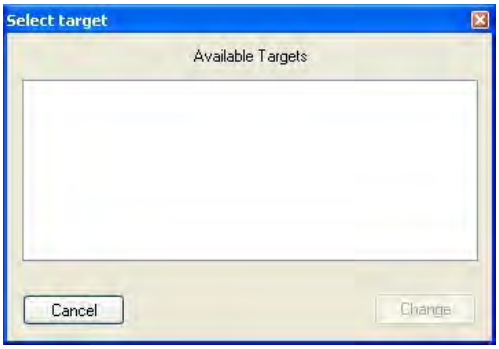


The information you enter here is shown in any printed document and may also be downloaded to the target device.

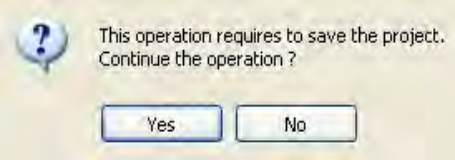
4.7 SELECTING THE TARGET DEVICE

You may need to port a PLC application on a target device which differs from that you originally wrote the code for. Follow the instructions below to adapt your LogicLab project to a new target device.

1) Click *Select target* in the *Project* menu of the LogicLab main window. This causes the following dialog box to appear.



2) Select one of the target devices listed in the combo box.
3) Click *Change* to confirm your choice, *Cancel* to abort.
4) If you confirm, LogicLab displays the following dialog box.



Press *Yes* to complete the conversion, *No* to quit.

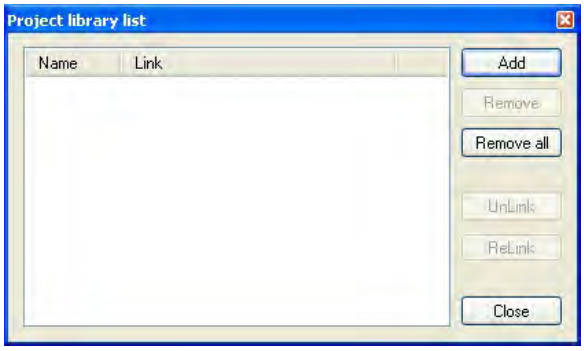
If you press *Yes*, LogicLab updates the project to work with the new target.

It also makes a backup copy of the project file(s) in a sub-directory inside the project directory, so that you can roll-back the operation by manually (i.e., using Windows Explorer) replacing the project file(s) with the backup copy.

4.8 WORKING WITH LIBRARIES

Libraries are a powerful tool for sharing objects between LogicLab projects. Libraries are usually stored in dedicated source file, whose extension is *.pll*.

4.8.1 THE LIBRARY MANAGER



The library manager lists all the libraries currently included in a LogicLab project. It also allows you to include or remove libraries.

To access the library manager, click *Library manager* in the *Project* menu.

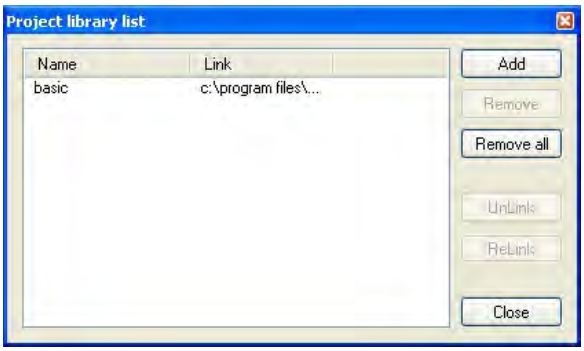
4.8.1.1 INCLUDING A LIBRARY

The following procedure shows you how to include a library in a LogicLab project, which results in all the library's objects becoming available to the current project.

Including a library means that a reference to the library's *.pll* file is added to the current project, and that a local copy of the library is made. Note that you cannot edit the elements of an included library, unlike imported objects.

If you want to copy or move a project which includes one or more libraries, make sure that references to those libraries are still valid in the new location.

1) Click *Library manager* in the *Project* menu, which opens the *Library manager* dialog box.
2) Press the *Add* button, which causes an explorer dialog box to appear, to let you select the *.pll* file of the library you want to open.
3) When you have found the *.pll* file, open it either by double-clicking it or by pressing the *Open* button. The name of the library and its absolute pathname are now displayed in a new row at the bottom of the list in the white box.

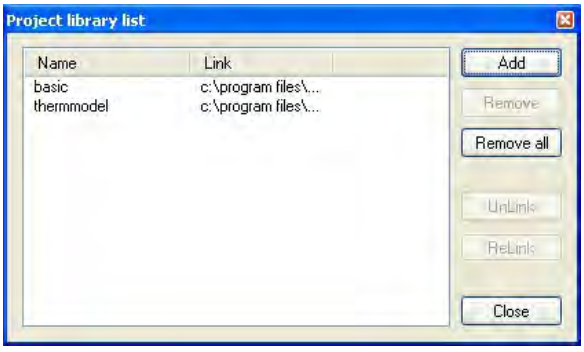


4) Repeat step 1, 2, and 3 for all the libraries you wish to include.
5) When you have finished including libraries, press either *OK* to confirm, or *Cancel* to quit.

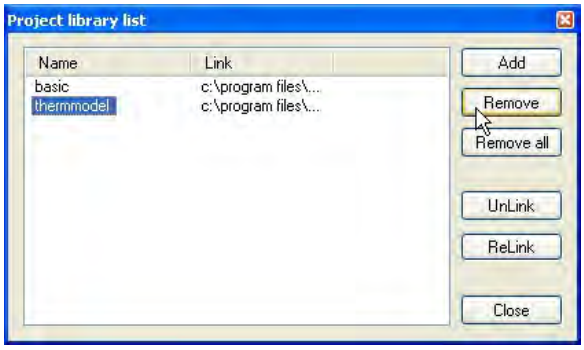
4.8.1.2 REMOVING A LIBRARY

The following procedure shows you how to remove an included library from the current project. Remember that removing a library does not mean erasing the library itself, but the project's reference to it.

1) Click *Library manager* in the *Project* menu of the LogicLab main window, which opens the *Library manager* dialog box.



2) Select the library you wish to remove by clicking its name once. The *Remove* button is now enabled.



3) Click the *Remove* button, which causes the reference to the selected library to disappear from the *Project library* list.

4) Repeat for all the libraries you wish to remove. Alternatively, if you want to remove all the libraries, you can press the *Remove all* button.

5) When you have finished removing libraries, press either *OK* to confirm, or *Cancel* not to apply changes.

4.8.2 EXPORTING TO A LIBRARY

You may export an object from the currently open project to a library, in order to make that object available to other projects. The following procedure shows you how to export objects to a library.

1) Look for the object you want to export by browsing the tree structure of the project tab of the *Workspace* bar, then click once the name of the object.

2) Click *Export object to library* in the *Project* menu. This causes the following dialog box to appear.

3) Enter the destination library by specifying the location of its *.pll* file. You can do this by:
   - typing the full pathname in the white text box;
   - clicking the *Browse* button , in order to open an explorer dialog box which allows you to browse your disk and the network.

4) You may optionally choose to encrypt the source code of the POU you are exporting, in order to protect your intellectual property.

5) Click *OK* to confirm the operation, otherwise press *Cancel* to quit.

If at Step 3 of this procedure you enter the name of a non-existing *.pll* file, LogicLab creates the file, thus establishing a new library.

4.8.2.1 UNDOING EXPORT TO A LIBRARY

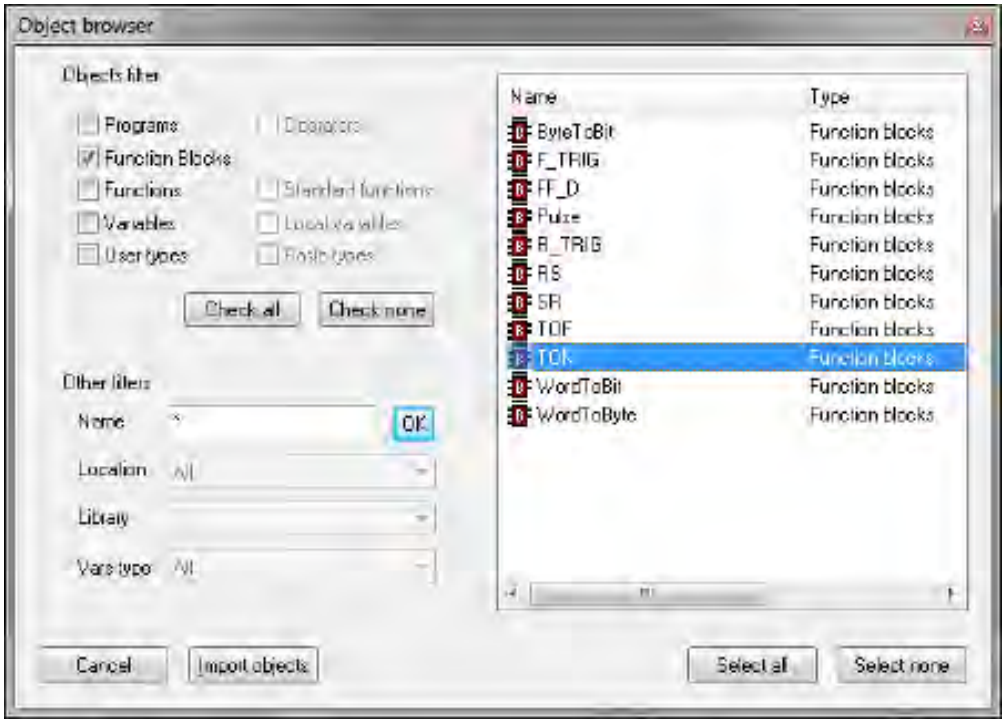
So far, it is not possible to undo export to a library. The only possibility to remove an object is to create another library containing all the objects of the current one, except the one you wish to delete.

4.8.3 IMPORTING FROM A LIBRARY OR ANOTHER SOURCE

You can import an object from a library in order to use it in the current project. When you import an object from a library, the local copy of the object loses its reference to the original library and it belongs exclusively to the current project. Therefore, you can edit imported objects, unlike objects of included libraries.

There are two ways of getting a POU from a library. The following procedure shows you how to import objects from a library.

1) Click *Import object from library* in the *Project* menu. This causes an explorer dialog box to appear, which lets you select the *.pll* file of the library you want to open.
2) When you have found the *.pll* file, open it either by double-clicking it or by pressing the *Open* button. The dialog box of the library explorer appears in foreground. Each tab in the dialog box contains a list of objects of a type consistent with the tab's title.



3) Select the tab of the type of the object(s) you want to import. You can also make simple queries on the objects in each tab by using *Filters*. However, note that only the *Name* filter actually applies to libraries. To use it, select a tab, then enter the name of the desired object(s), even using the * wildcard, if necessary.
4) Select the object(s) you want to import, then press the *Import object* button.
5) When you have finished importing objects, press indifferently *OK* or *Cancel* to close the *Library* browser.

4.8.3.1 UNDOING IMPORT FROM A LIBRARY

When you import an object in a LogicLab project, you actually make a local copy of that object. Therefore, you just need to delete the local object in order to undo import.

5. MANAGING PROJECT ELEMENTS

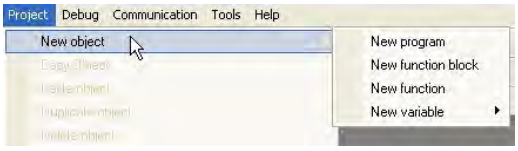
This chapter shows you how to deal with the elements which compose a project, namely: Program Organization Units (briefly, POUs), tasks, derived data types, and variables.

5.1 PROGRAM ORGANIZATION UNITS

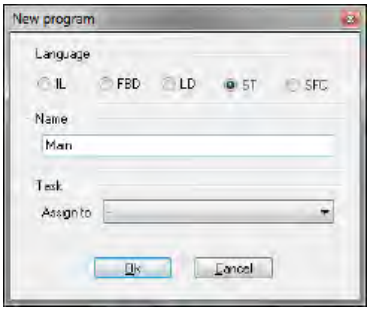
This paragraph shows you how to add new POUs to the project, how to edit and eventually remove them.

5.1.1 CREATING A NEW PROGRAM ORGANIZATION UNIT

1) Select the *New object* item in the *Project* menu.



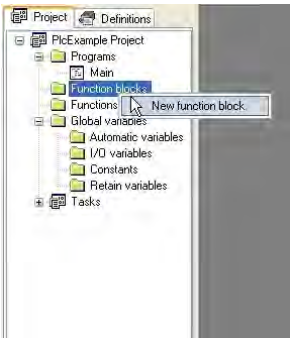
2) Specify what kind of POU you want to create by clicking one of the items in the submenu which pops up.
3) Select the language you will use to implement the POU.



Enter the name of the new module.

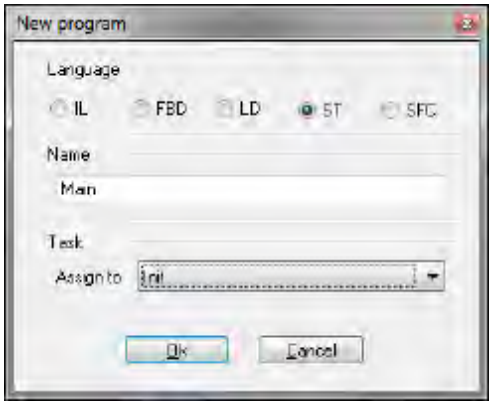
4) Confirm the operation by clicking on the *OK* button.

Alternatively, you can create a new POU of a specific type (program, function block, or function) by right-clicking on the correspondent item of the project tree.



5.1.1.1 ASSIGNING A PROGRAM TO A TASK AT CREATION TIME

When creating a new program, LogicLab gives you the chance to assign that program to a task at the same time: select the task you want the program to be assigned to from the list shown in the *Task* section of the *New program* window.

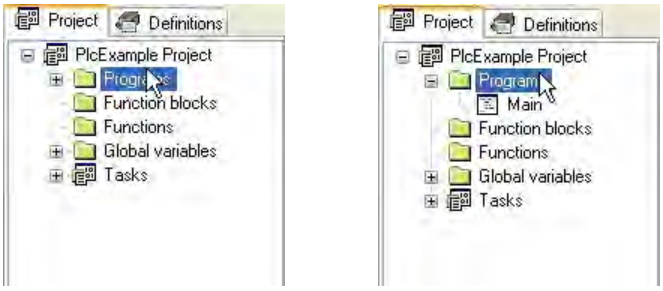


5.1.2 EDITING POUS

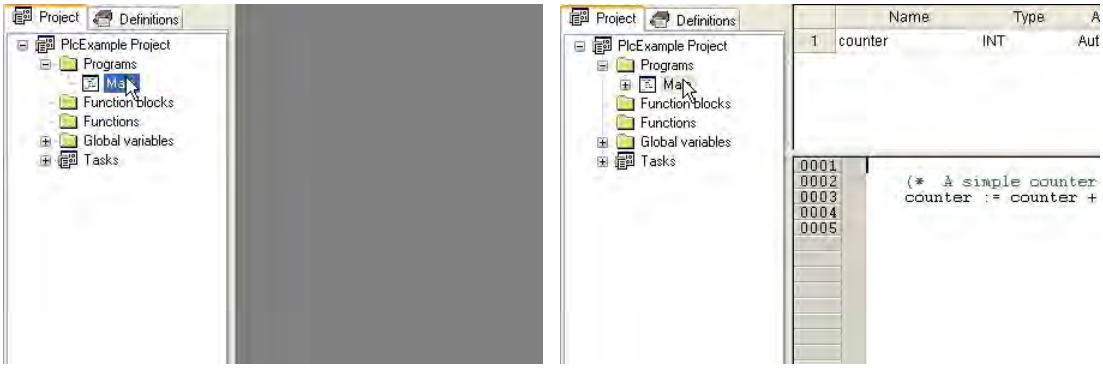
All the POUs of the project are listed in the *Programs*, *Function blocks*, and *Functions* folders in the *Project* tab of the *Workspace* bar.

The following procedure shows you how to edit the source code of an existing POU.

1) Open the folder in the *Project* tab of the workspace that contains the object you want to edit by double-clicking the folder name.

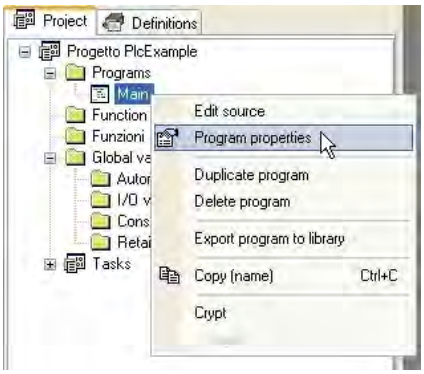


2) Double-click the name of the object you want to edit. The relative editor opens and lets you modify the source code of the POU.

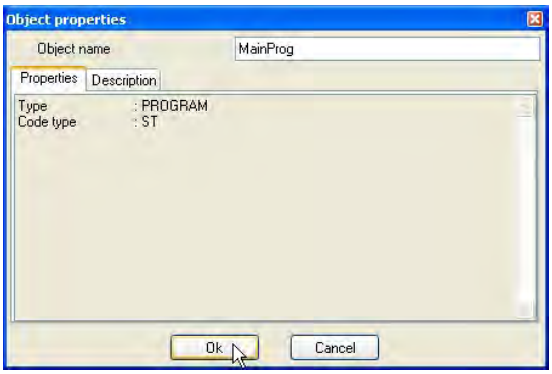


You may want to change the name of the POU:

1) Open the *Object properties* editor from the contextual menu which pops up when right-clicking the POU name in the project tree (alternatively, select the correspondent item in the *Project* menu).

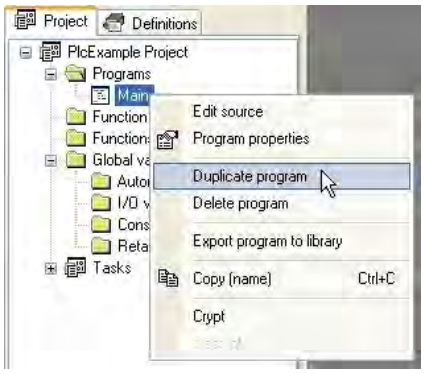


2) Change the object name and confirm.



Finally, you can create a duplicate of the POU in this way:

1) Select *Duplicate* from the contextual menu (or the *Project* menu).



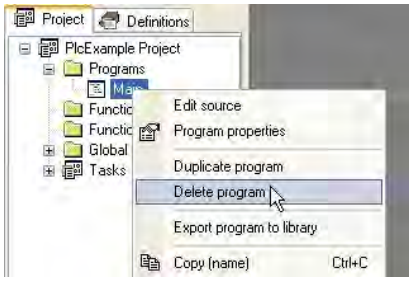
2) Enter the name of the new POU and confirm.

5.1.3 DELETING POUS

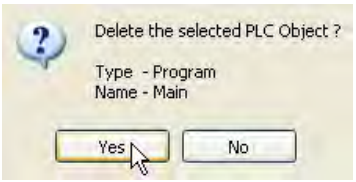
Follow this procedure to remove a POU from your project:

1) Open the folder in the *Project* tab of the workspace that contains the object you want to delete by double-clicking the folder name.

2) Right-click the name of the object you want to delete. A context menu appears referred to the selected object.



3) Click *Delete object* in the context menu, then press *Yes* to confirm your choice.



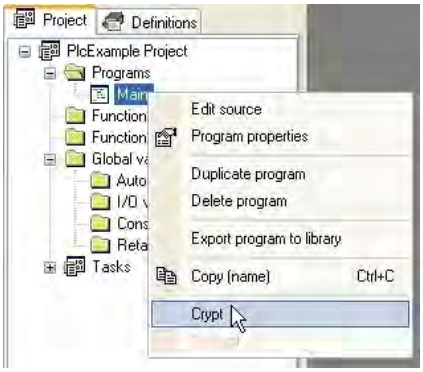
5.1.4 SOURCE CODE ENCRYPTION

You may want to hide the source code of one or more POUs.

LogicLab lets you encrypt POUs and protect them with a password.

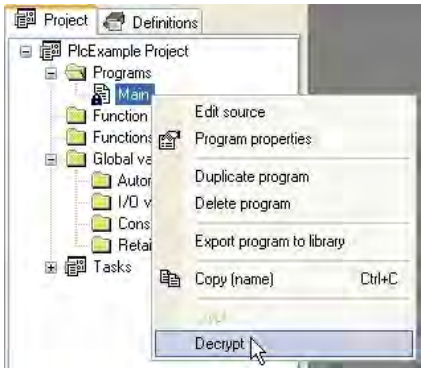
To encrypt a POU, perform the following steps:

1) Right-click the POU name in the project tree and choose *Crypt* from the contextual menu.



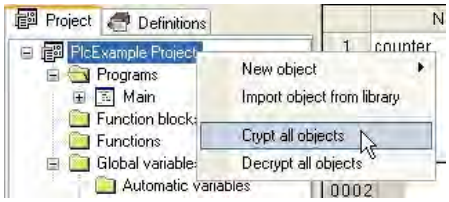
2) Enter the password twice (to avoid any problem which may arise from typos) and confirm the operation.

To decrypt a POU, right-click the POU name in the project tree and choose *Decrypt* from the contextual menu.



LogicLab prompt you to enter the password.

You can choose to encrypt all the unencrypted POUs at once:



the same password applies to all objects.

5.2 VARIABLES

There are two classes of variables in LogicLab: global variables and local variables.

This paragraph shows you how to add to the project, edit, and eventually remove both global and local variables.

5.2.1 GLOBAL VARIABLES

Global variables can be seen and referenced by any module of the project.

5.2.1.1 CLASSES OF GLOBAL VARIABLES

Global variables are listed in the project tree, in the *Global variables* folder, where they are further classified according to their properties as Automatic variables, Mapped variables, Constants, and Retain variables.

- Automatic variables include all the variables that the compiler automatically allocates to an appropriate location in the target device memory.
- Mapped variables, on the other way, do have an assigned address in the target device logical addressing system, which shall be specified by the developer.
- Constants list all the variables which the developer declared as having the `CONSTANT` attribute, so that they cannot be written.
- Retain variables list all the variables which the developer declared as having the `RETAIN` attribute, so that their values are stored in a persistent memory area of the target device.

5.2.1.2 GROUPS OF GLOBAL VARIABLES

You can further categorize the set of all global variables by grouping them according to application-specific criteria. In order to define a new group, follow this procedure:

1) Select *Group* from the *Variables* menu (note that this menu is available only if the *Global variables* editor is open).

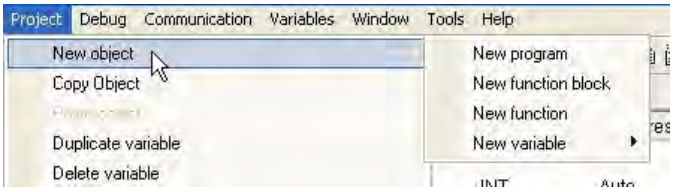
2) Enter the name of the new variable group, then click *Add*.

3) You can now use the variable group in the declaration of new global variables.

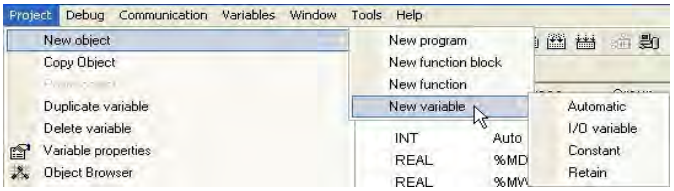
5.2.1.3 CREATING A NEW GLOBAL VARIABLE

Apply the following procedure to declare a new global variable:

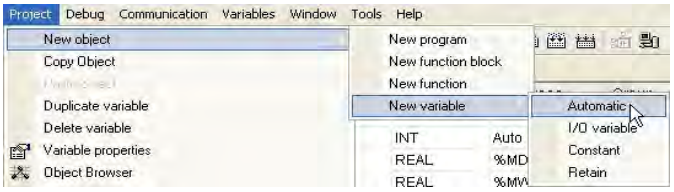
1) Select *New object* in the *Project* menu.



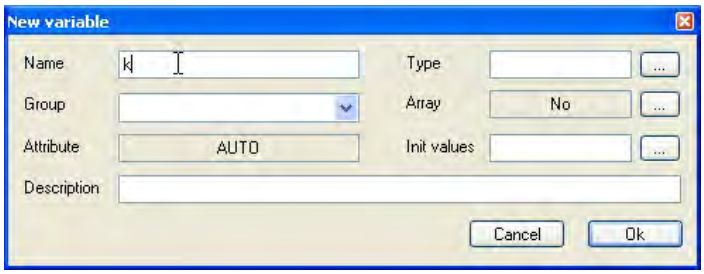
2) Select *New variable* from the menu that shows up.



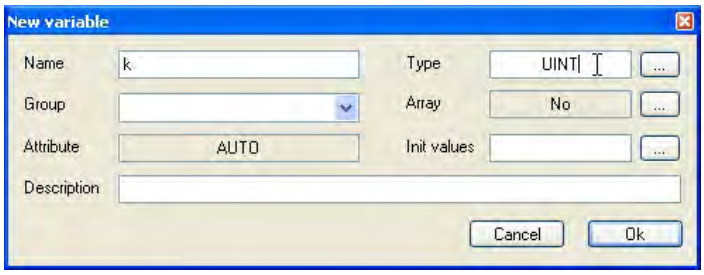
3) Choose the class of the variable you want to declare (Automatic variables, Mapped variables, Constants, or Retain variables).



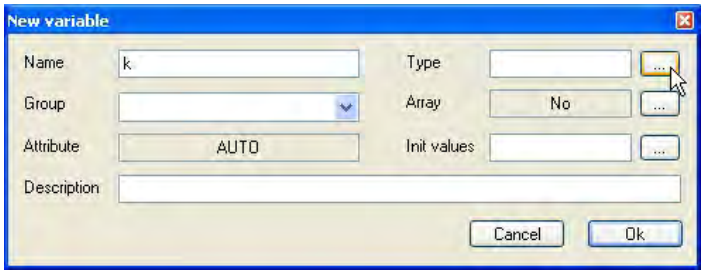
4) Enter the name of the variable (remember that some characters, such as '?', '.', '/', and so on, cannot be used: the variable name must be a valid IEC 61131-3 identifier).

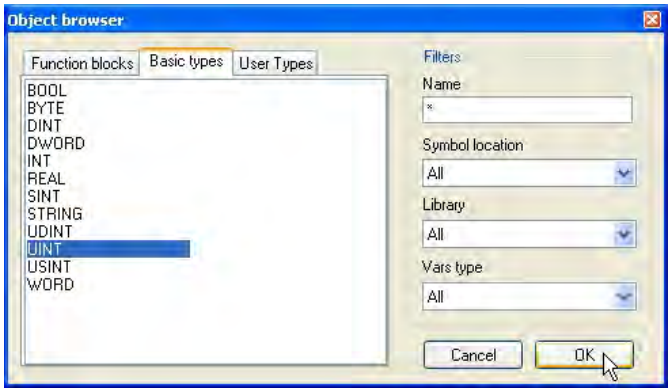


5) Specify the type of the variable either by typing it

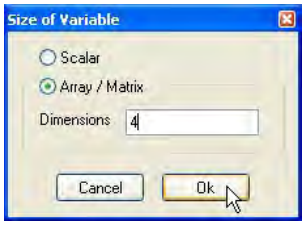


or by selecting it from the list that LogicLab displays when you click on the *Browse* button.

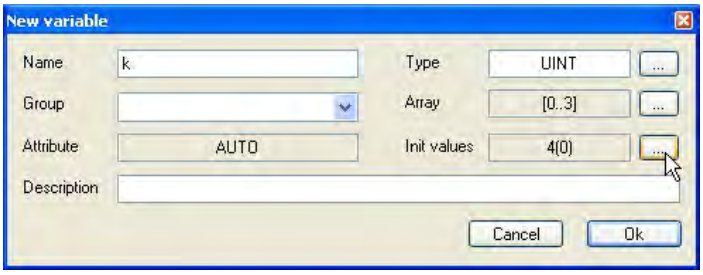


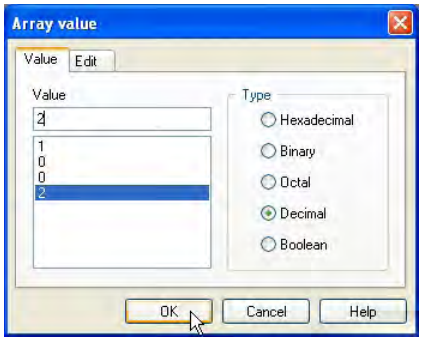


6) If you want to declare an array, you can specify its size.

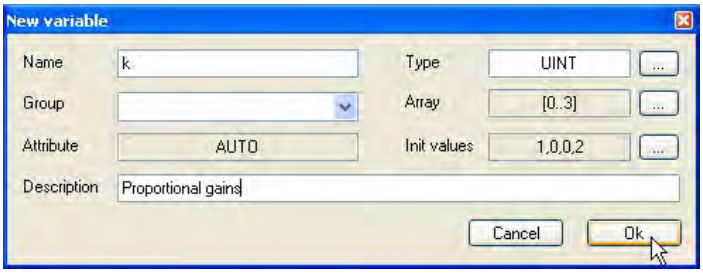


7) You may optionally assign the initial value to the variable.



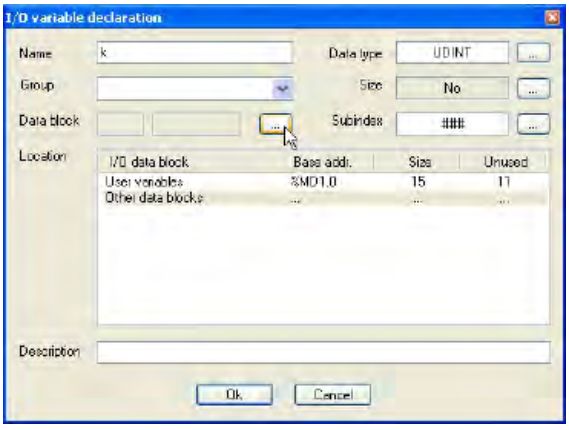


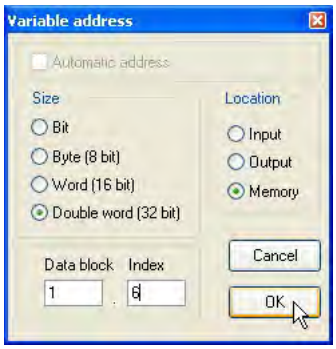
8) Finally, you can add a brief description and then confirm the operation.



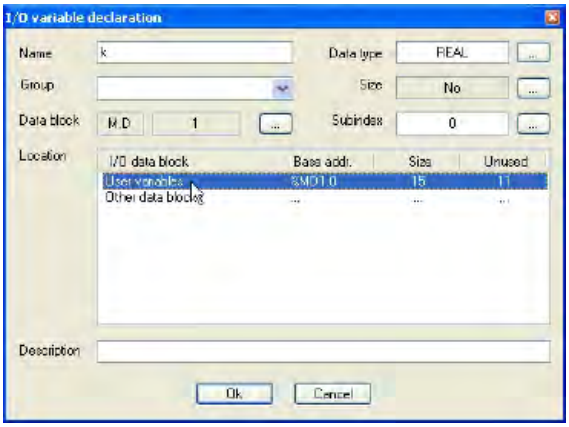
If you create a new mapped variable, you are required to specify the address of the variable during its definition. In order to do so, you may do one of the following actions:

- Click on the button to open the editor of the address, then enter the desired value.





- Select from the list that LogicLab shows you the memory area you want to use: the tool automatically chooses the address of the first free memory location of that area.



5.2.1.4 EDITING A GLOBAL VARIABLE

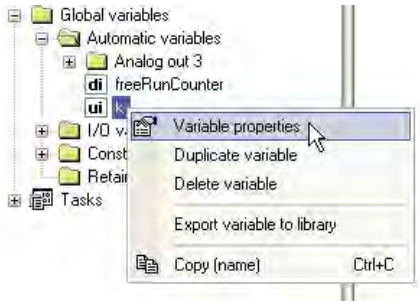
To edit the definition of an existing global variable:

1) Open the folder in the *Project* tab of the workspace that contains the variable you want to edit.

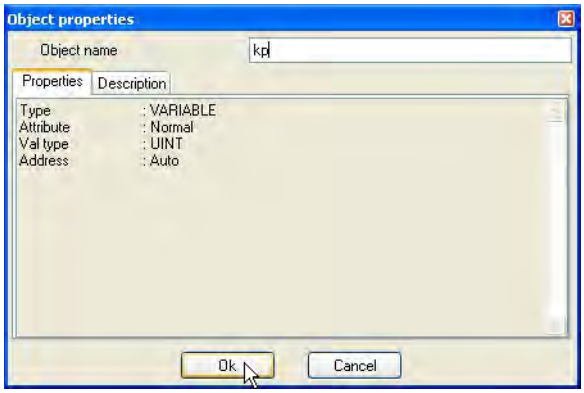
2) Double-click the name of the variable you want to edit: the global variables editor opens and lets you modify its definition.

If you just want to change the name of the variable:

1) Open the *Variable properties* editor from the contextual menu which pops up when right-clicking the variable name in the project tree (alternatively, select the correspondent item in the *Project* menu).

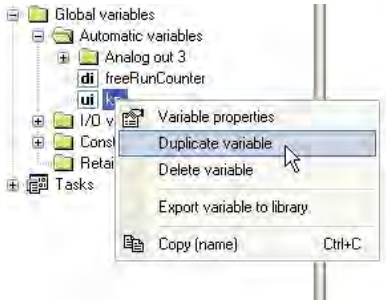


2) Change the variable name and confirm.



Finally, you can create a duplicate of the variable in this way:

1) Select *Duplicate variable* from the contextual menu (or the *Project* menu).

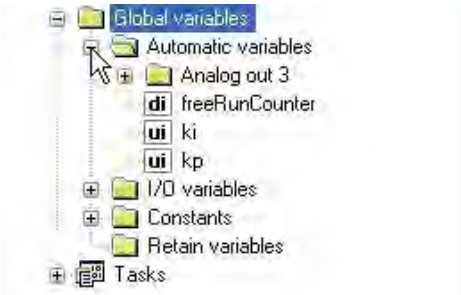


2) Enter the name of the new variable and confirm.

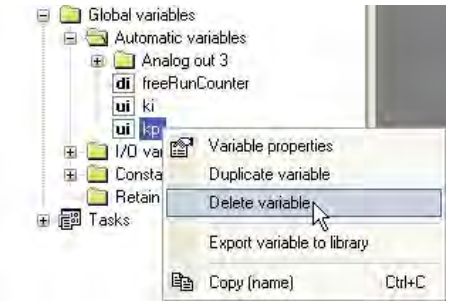
5.2.1.5 DELETING A GLOBAL VARIABLE

Follow this procedure to remove a global variable from your project:

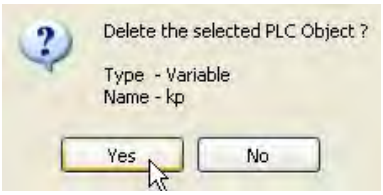
1) Open the folder in the *Project* tab of the workspace that contains the variable you want to delete.



2) Right-click the name of the variable you want to delete. A context menu appears referred to the selected variable.



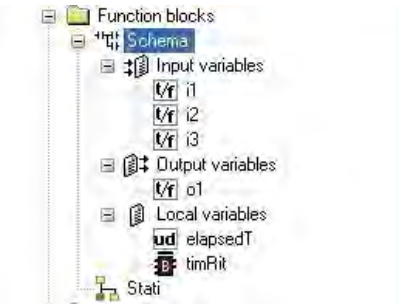
3) Click *Delete variable* in the context menu, then press *Yes* to confirm you choice.



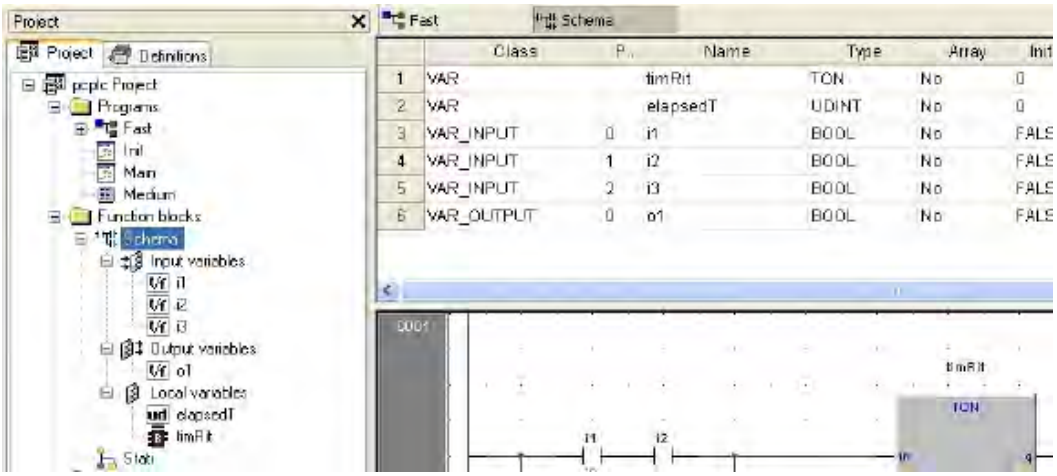
5.2.2 LOCAL VARIABLES

Local variables are declared within a POU (either program, or function, or function block), the module itself being the only project element which can refer to and access them.

Local variables are listed in the project tree under the POU which declares them (only when that POU is open for editing), where they are further classified according to their class (e.g., as input or inout variables).



In order to create, edit, and delete local variables, you have to open the Program Organization Unit for editing and use the local variables editor.



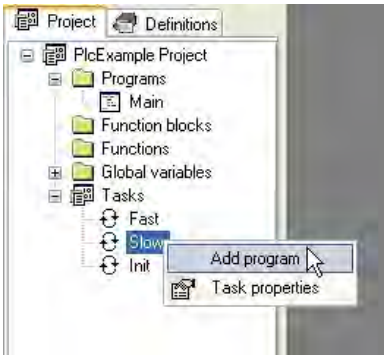
Refer to the corresponding section in this manual for details (see Paragraph 6.6.1.2).

5.3 TASKS

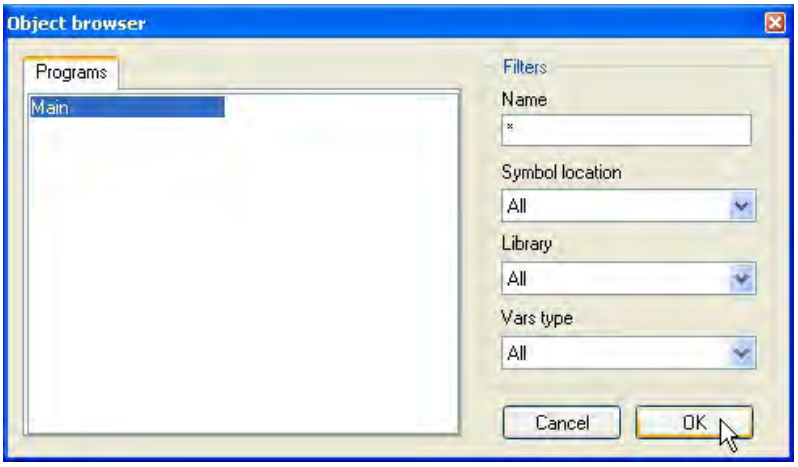
5.3.1 ASSIGNING A PROGRAM TO A TASK

Read the instructions below to know how to make a task execute a program.

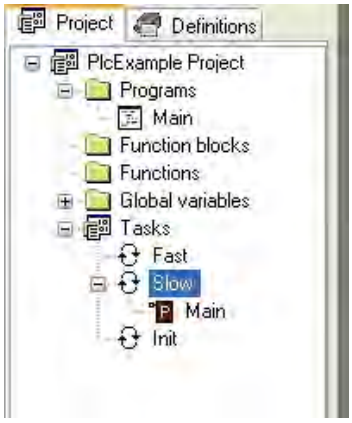
1) The tasks running on the target device are listed in the *Project* tab of the *Workspace* window. Right-click the name of the task you want to execute the program and choose *Add program* from the contextual menu.



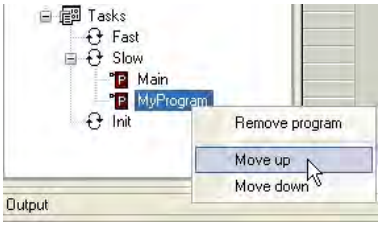
2) Select the program you want the task to execute from the list which shows up and confirm your choice.



3) The program has been assigned to the task, as you can see in the project tree.



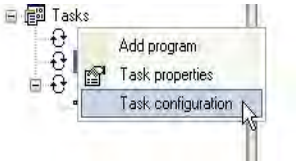
Note that you can assign more than a program to a task. From the contextual menu you can sort and, eventually, remove program assignments to tasks.



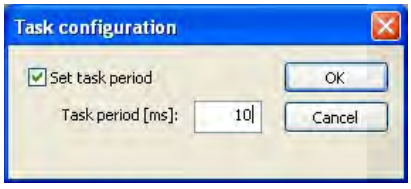
5.3.2 TASK CONFIGURATION

Depending on the target device you are interfacing with, you may have the chance to configure some of the PLC tasks' settings.

1) Select the *Task configuration* item in the contextual menu which pops up, if you right-click on the name of the task you want to configure.



2) In the *Task configuration* window you can edit the task execution period.



5.4 DERIVED DATA TYPES

The *Definitions* section of the *Workspace* window lets you define derived data types.

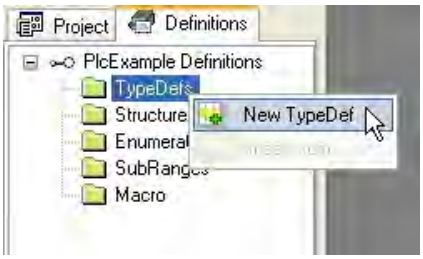
5.4.1 TYPEDEFS

The following paragraphs show you how to manage typedefs.

5.4.1.1 CREATING A NEW TYPEDEF

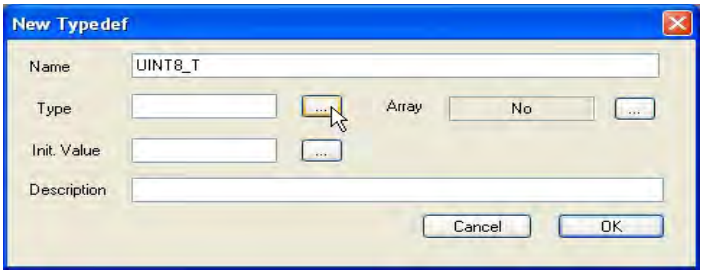
In order to define a new typedef follow this procedure:

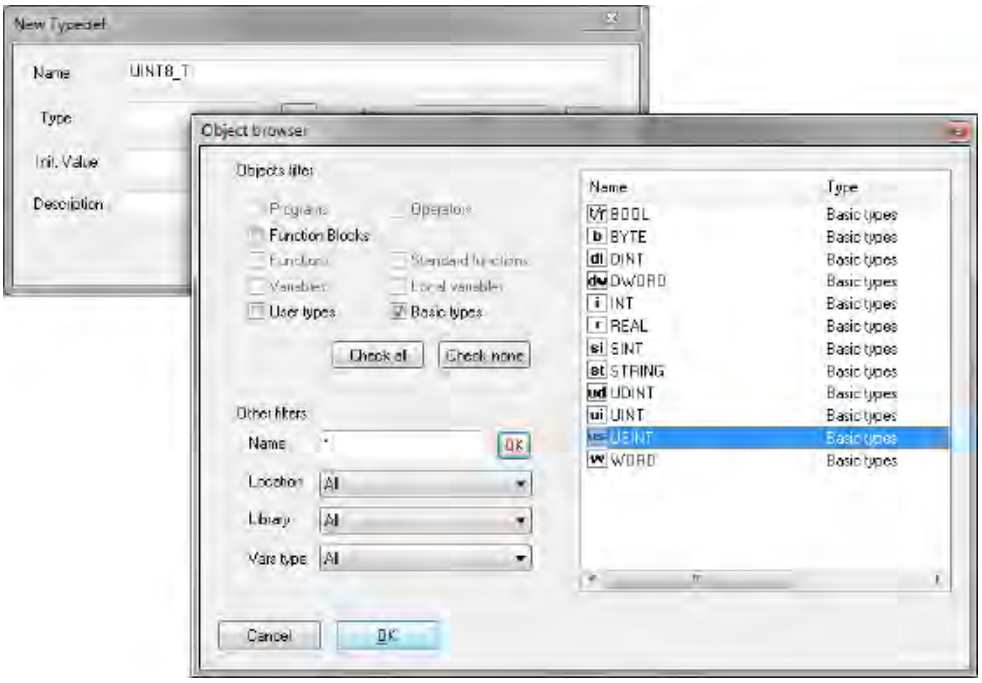
1) Right-click the *TypeDefs* folder and choose *New TypeDef* from the contextual menu.



2) Type the name of the typedef.

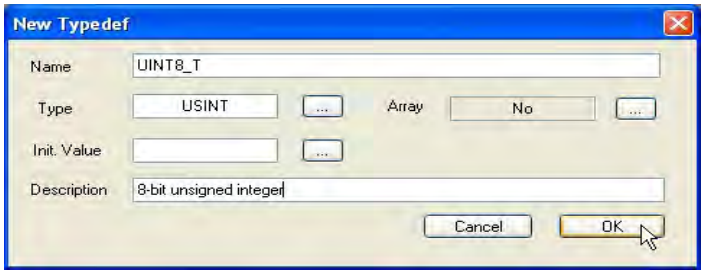
3) Select the type you are defining an alias for





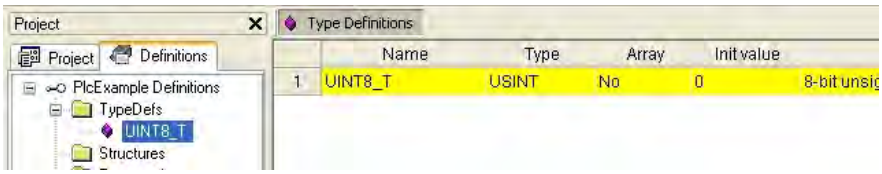
(if you want to define an alias for an array type, you shall choose the array size).

4) Enter a meaningful description (optional) and confirm the operation.



5.4.1.2 EDITING A TYPEDEF

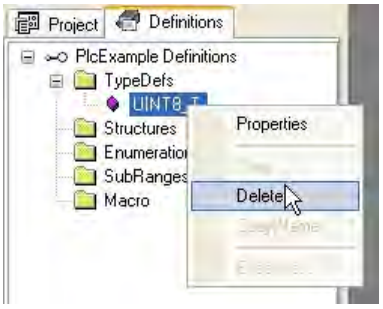
The typedefs of the project are listed under the *TypeDefs* folder. In order to edit a typedef you just have to double-click on its name.



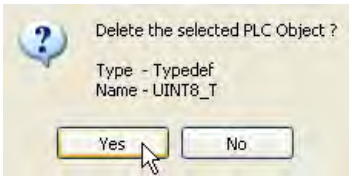
5.4.1.3 DELETING A TYPEDEF

To delete a typedef, follow this procedure:

1) Right-click the typedef name and choose *Delete* from the contextual menu.



2) Confirm your choice.



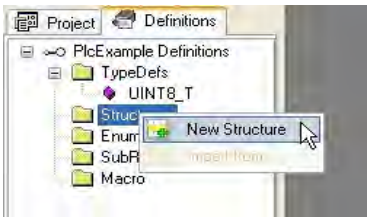
5.4.2 STRUCTURES

The following paragraphs show you how to manage structures.

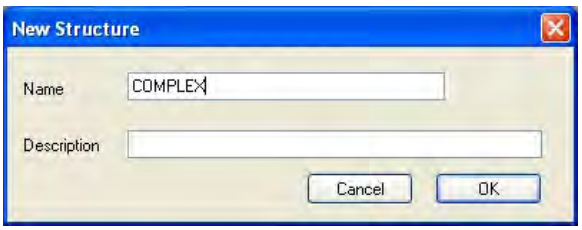
5.4.2.1 CREATING A NEW STRUCTURE

Follow this procedure to create a new structure:

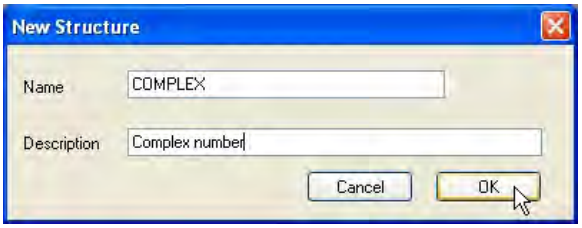
1) Right-click the *Structures* folder and choose *New structure* from the contextual menu.



2) Type the name of the structure.

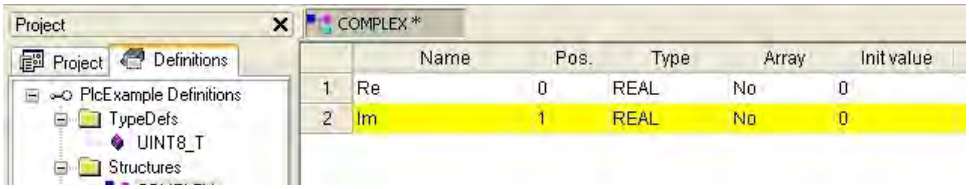


3) Enter a meaningful description and confirm the operation.



5.4.2.2 EDITING A STRUCTURE

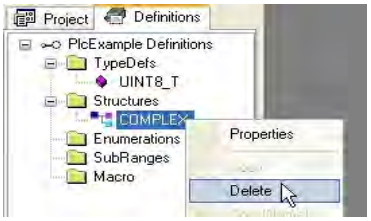
The structures of the project are listed under the *Structures* folder. In order to edit a structure (for example, to define its fields) you have to double-click on its name.



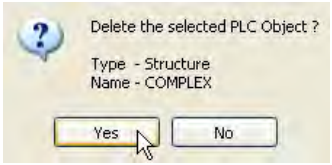
5.4.2.3 DELETING A STRUCTURE

Follow this procedure to delete a structure:

1) Right-click the structure name and choose *Delete* from the contextual menu.



2) Confirm your choice.



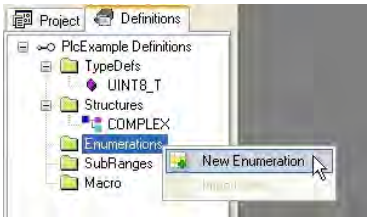
5.4.3 ENUMERATIONS

The following paragraphs show you how to manage enumerations.

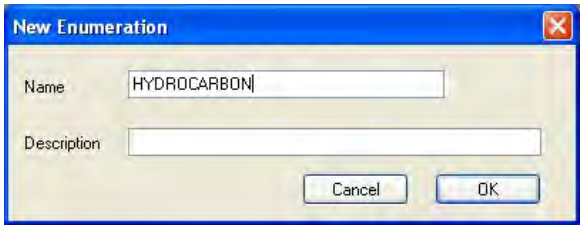
5.4.3.1 CREATING A NEW ENUMERATION

Follow this procedure to create a new enumeration:

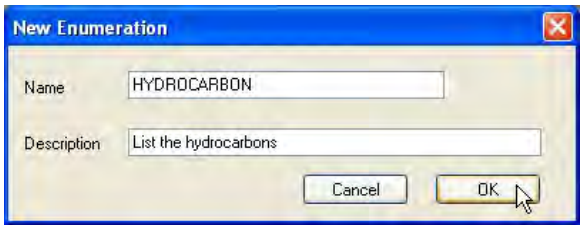
1) Right-click the *Enumerations* folder and choose *New enumeration* from the contextual menu.



2) Type the name of the enumeration.

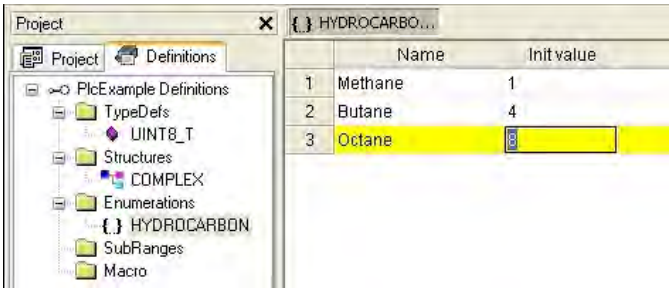


3) Enter a meaningful description and confirm the operation.



5.4.3.2 EDITING AN ENUMERATION

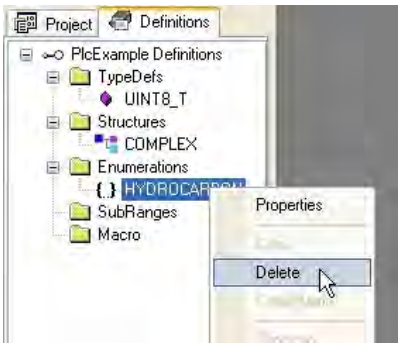
The enumerations of the project are listed under the *Enumerations* folder. In order to edit an enumeration (for example, to define its values) you have to double-click on its name.



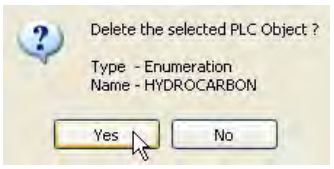
5.4.3.3 DELETING AN ENUMERATION

Follow this procedure to delete an enumeration:

1) Right-click the enumeration name and choose *Delete* from the contextual menu.



2) Confirm your choice.



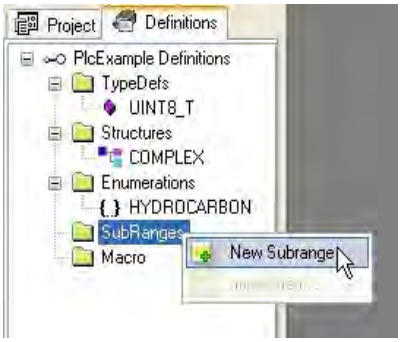
5.4.4 SUBRANGES

The following paragraphs show you how to manage subranges.

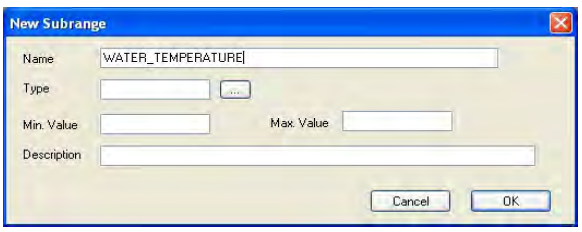
5.4.4.1 CREATING A NEW SUBRANGE

Follow this procedure to create a new subrange:

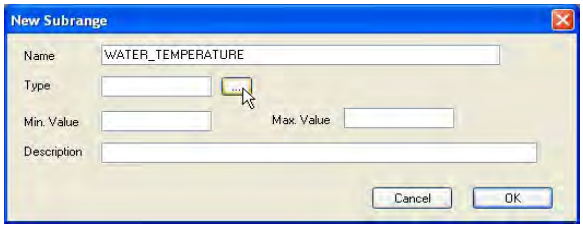
1) Right-click the *Subranges* folder and choose *New Subrange* from the contextual menu.

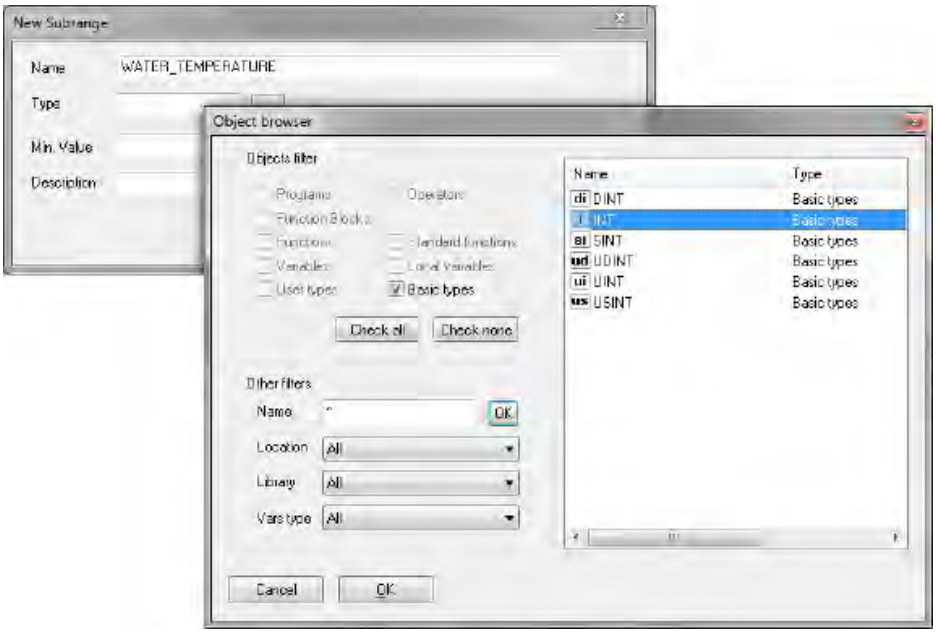


2) Type the name of the subrange.

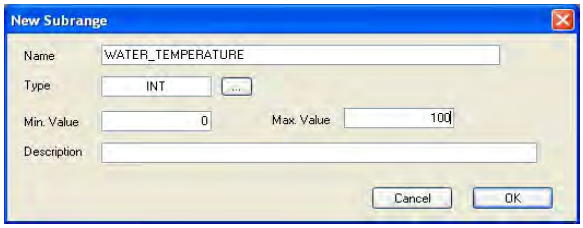


3) Select the basic type for the subrange.

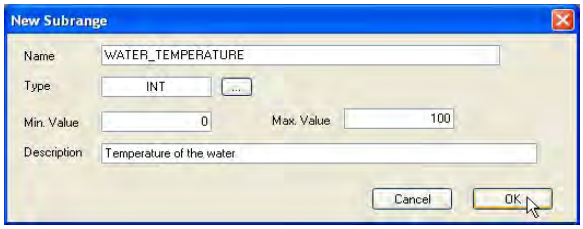




4) Enter minimum and maximum values of the subrange.

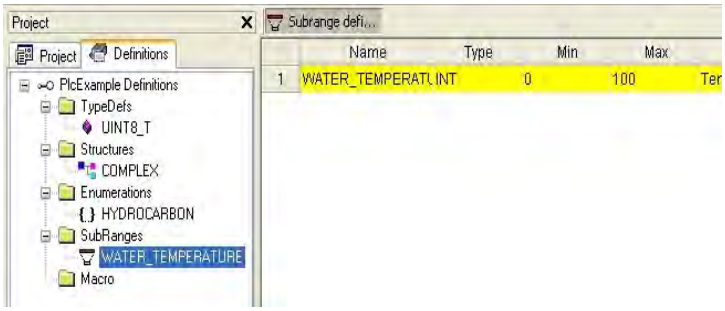


5) Enter a meaningful description (optional) and confirm the operation.



5.4.4.2 EDITING A SUBRANGE

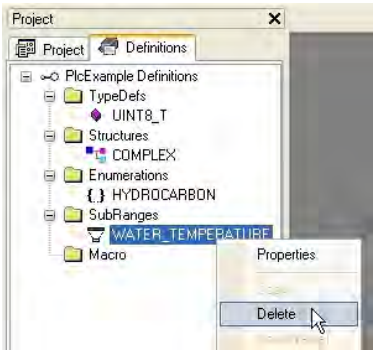
The subranges of the project are listed under the *Subranges* folder. In order to edit a subrange you just have to double-click on its name.



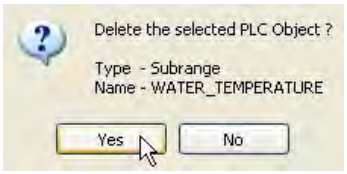
5.4.4.3 DELETING A SUBRANGE

Follow this procedure to delete a subrange:

1) Right-click the subrange name and choose *Delete* from the contextual menu.



2) Confirm your choice.

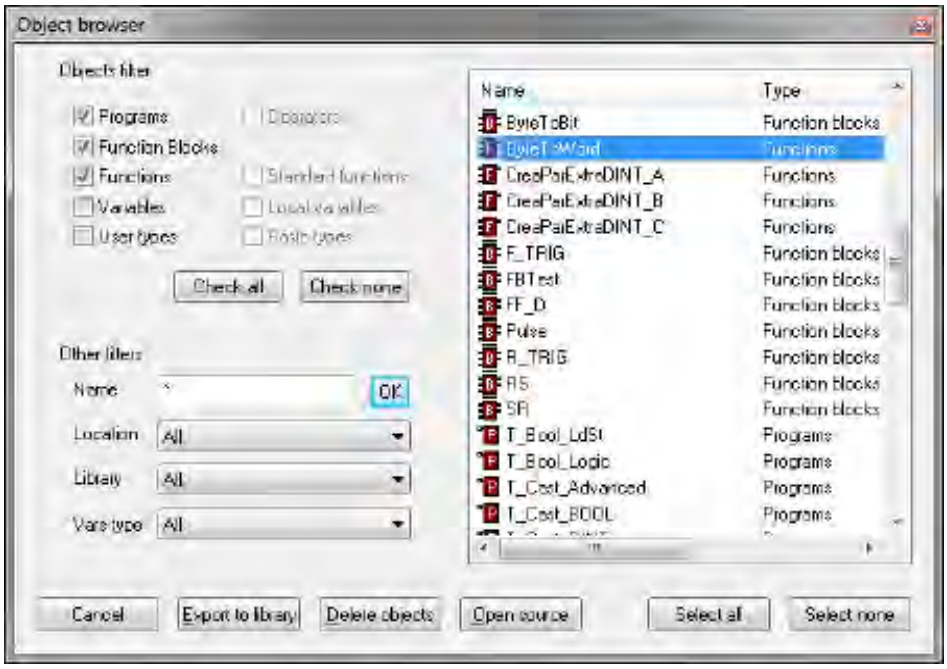


5.5 BROWSING THE PROJECT

Projects may grow huge, hence LogicLab provides two tools to search for an object within a project: the *Object browser* and the *Find in project* feature.

5.5.1 OBJECT BROWSER

LogicLab provides a useful tool for browsing the objects of your project: the *Object browser*.



This tool is context dependent, this implies that the kind of objects that can be selected and that the available operations on the objects in the different context are not the same.

Object browser can be opened in these three main ways:

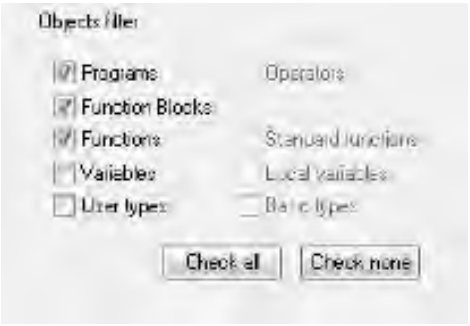
- *Browser* mode.
- *Import object* mode.
- *Select object* mode.

User interaction with *Object browser* is mainly the same for all the three modes and is described in the next paragraph.

5.5.1.1 COMMON CHARACTERISTICS AND USAGE OF OBJECT BROWSER

This section describes the features and the usage of the *Object browser* that are common to every mode in which *Object browser* can be used.

Objects filter

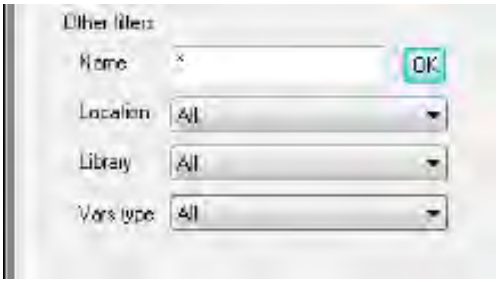


This is the main filter of the *Object browser*. User can check one of the available (enabled) object items.

In this example, *Programs*, *Function Blocks*, *Functions* are selected, so objects of this type are shown in the object list. *Variables* and *User types* objects can be selected by user but objects of that type are not currently shown in the object list. *Operators*, *Standard functions*, *Local variables*, and *Basic types* cannot be checked by user (because of the context) so cannot be browsed.

User can also click *Check all* button to select all available objects at one time or can click *Check none* button to deselect all objects at one time.

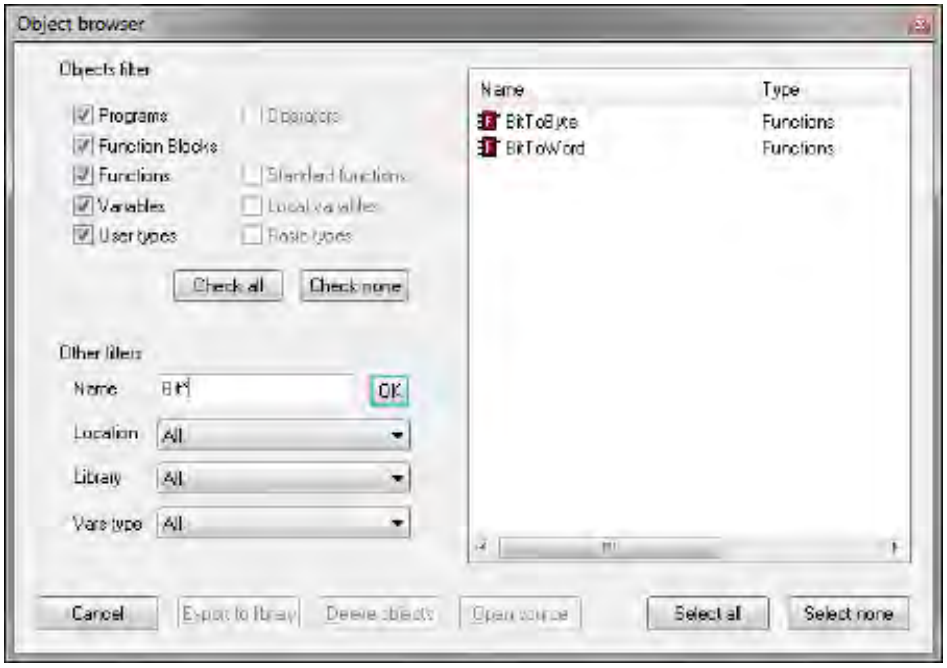
Other filters



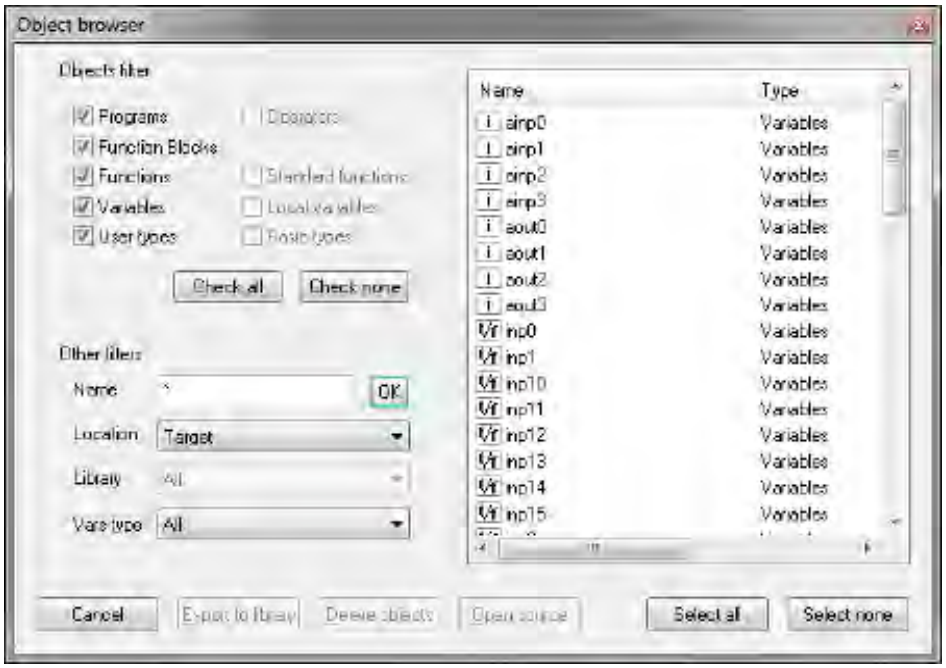
Selected objects can be also filtered by name, symbol location, specific library and var type.

Filters are all additive and are immediately applied after setting.

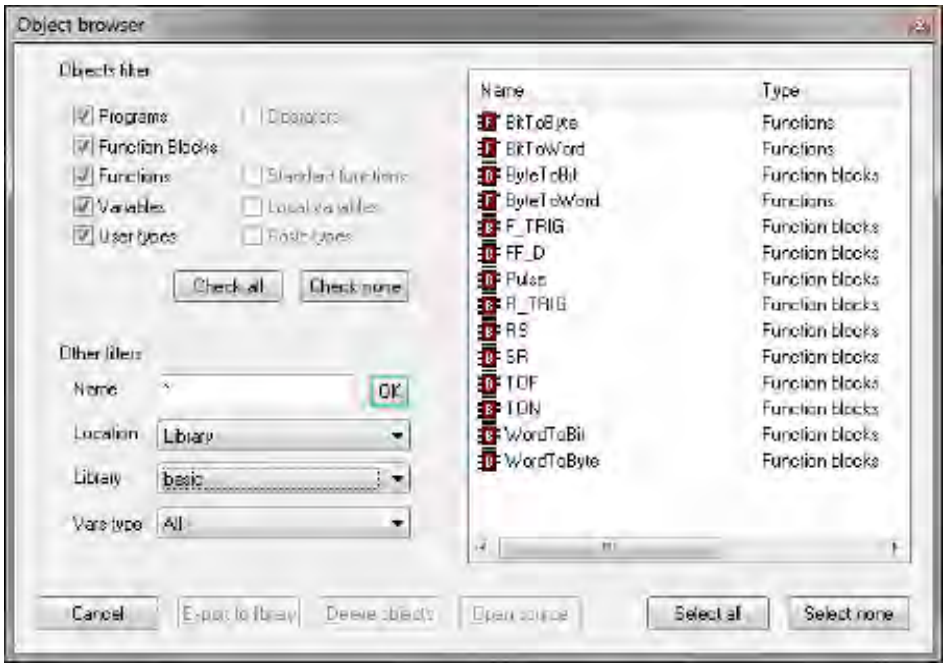
Name	
Function	Filters objects on the base of their name.
Set of legal values	All the strings of characters.
Use	Type a string to display the specific object whose name matches the string. Use the * wildcard if you want to display all the objects whose name contains the string in the *Name* text box. Type * if you want to disable this filter. Press *Enter* when edit box is focused or click on the *OK* button near the edit box to apply the filter.
Applies to	All object types.



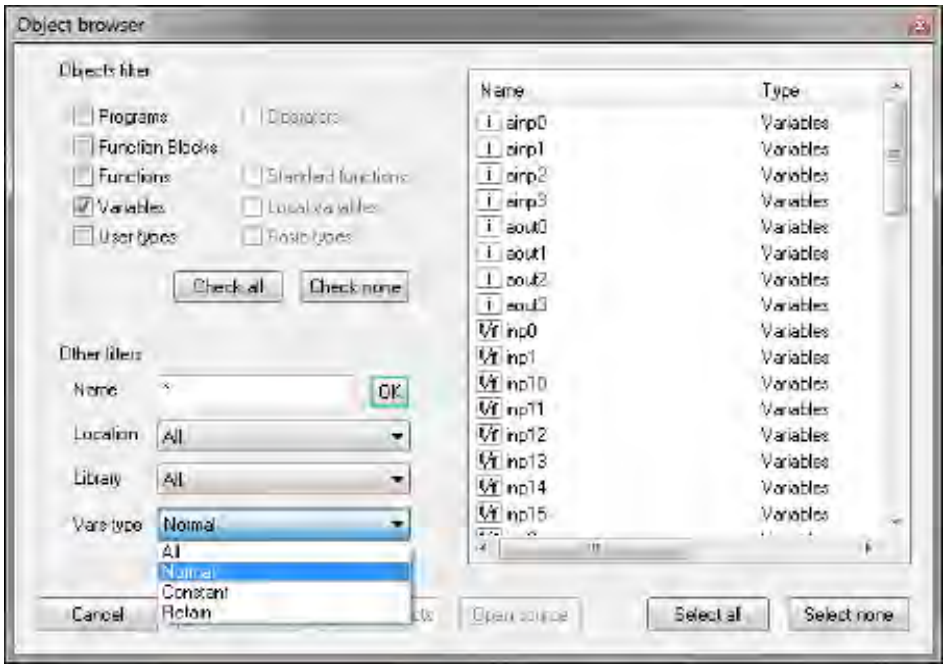
Symbol location	
Function	Filters objects on the base of their location.
Set of legal values	All, Project, Target, Library, Aux. Sources.
Use	All= Disables this filter. Project= Objects declared in the LogicLab project. Target= Firmware objects. Library= Objects contained in a library. In this case, use simultaneously also the *Library* filter, described below. Aux sources= Shows aux sources only.
Applies to	All objects types.



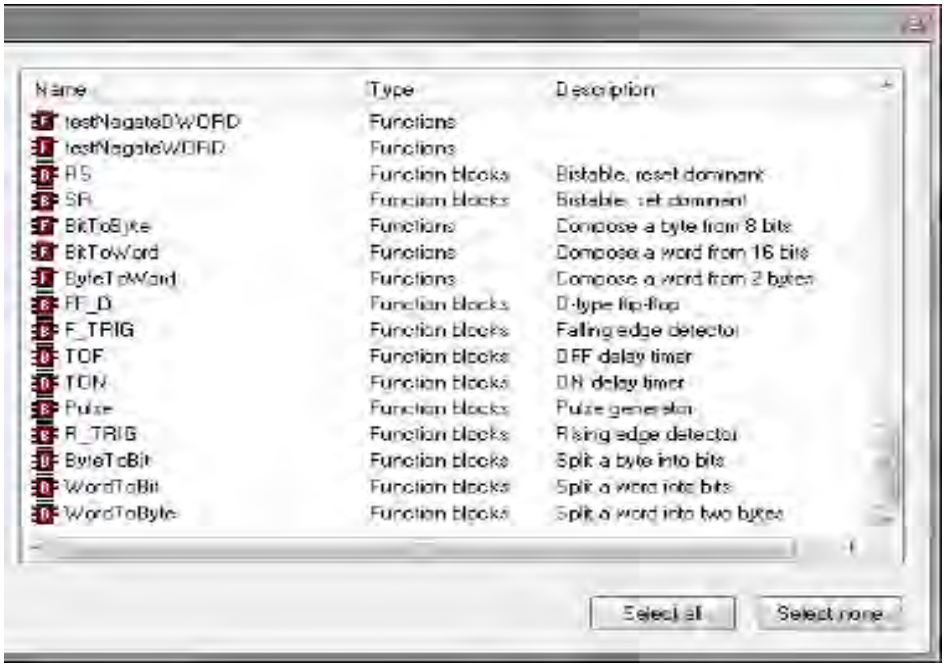
Library	
Function	Completes the specification of a query on objects contained in libraries. The value of this control is relevant only if the *Symbol location* filter is set to *Library*.
Set of legal values	All, libraryname1, libraryname2, ...
Use	All= Shows objects contained in whatever library. LibrarynameN= Shows only the objects contained in the library named librarynameN.
Applies to	All objects types.



Vars Type	
Function	Filters global variables and system variables (also known as firmware variables) according to their type.
Set of legal values	All, Normal, Constant, Retain
Use	All= Shows all the global and system variables. Normal= Shows normal global variables only. Constant= Shows constants only. Retain= Shows retain variables only.
Applies to	Variables.



Object list



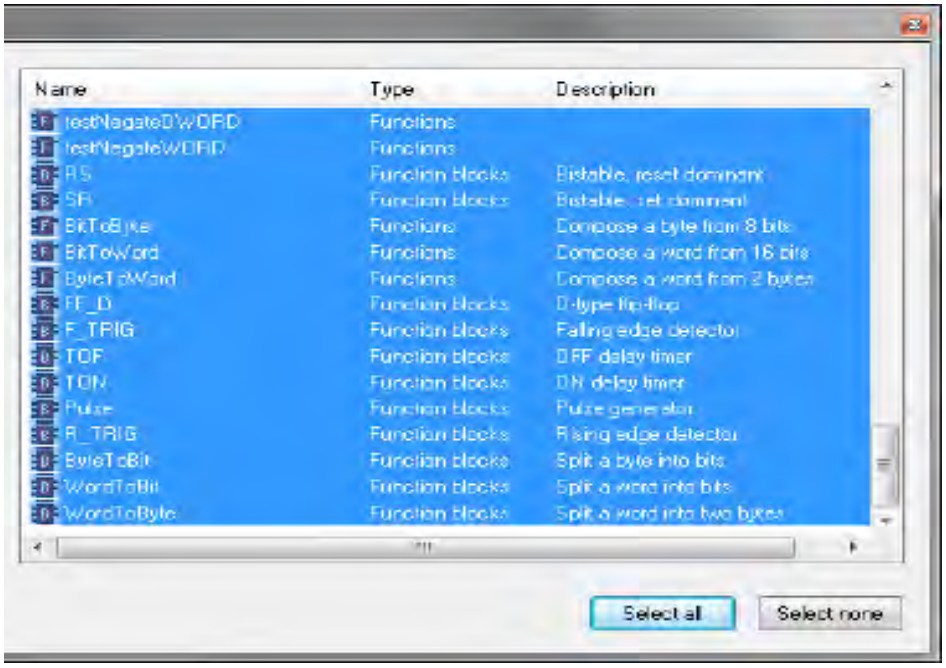
Object list shows all the filtered objects. List can be ordered in ascending or discending way by clicking on the header of the column. So it is possible to order items by *Name*, *Type*, or *Description*.

Double-clicking on an item allows the user to perform the default associated operation (the action is the same of the *OK*, *Import object*, or *Open source* button actions).

When item multiselection is allowed, *Select all* and *Select none* buttons are visible.

It is possible to select all objects by clicking on *Select all* button. *Select none* deselects all objects.

If at least an item is selected on the list operation, buttons are enabled.



Resize

Window can be resized, the cursor changes along the border of the dialog and allows the user to resize window. When reopened, *Object browser* dialog takes the same size and position of the previous usage.

Close dialog

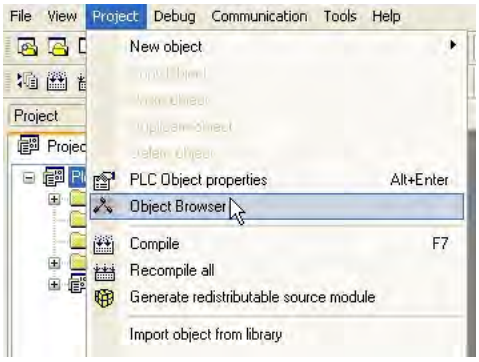
You have two options for closing the *Object browser*:

- Press the button near the right-end border of the caption bar.

- Press the *Cancel/OK* button below the filter box.

5.5.1.2 USING OBJECT BROWSER AS A BROWSER

To use *Object browser* in this way click on *Object browser* in the *Project* menu. This causes the *Object browser* dialog box to appear, which lets you navigate between the objects of the currently open project.



Available objects

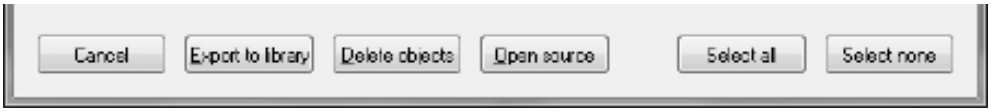
In this mode you can list objects of these types:

- Programs.
- Function Blocks.
- Functions.
- Variables.
- User types.

These items can be checked or unchecked in *Objects filter* section to show or to hide the objects of the chosen type in the list.

Other types of objects (Operators, Standard functions, Local variables, Basic types) cannot be browsed in this context so they are unchecked and disabled).

Available operations



Allowed operations in this mode are:

Open source, default operation for double-click on an item	
Function	Opens the editor by which the selected object was created and displays the relevant source code.
Use	If the object is a program, or a function, or a function block, this button opens the relevant source code editor. If the object is a variable, then this button opens the variable editor. Select the object whose editor you want to open, then click on the *Open source* button.

Export to library	
Function	To export an object to a library.
Use	Select the objects you want to export, then press the *Export to library* button.

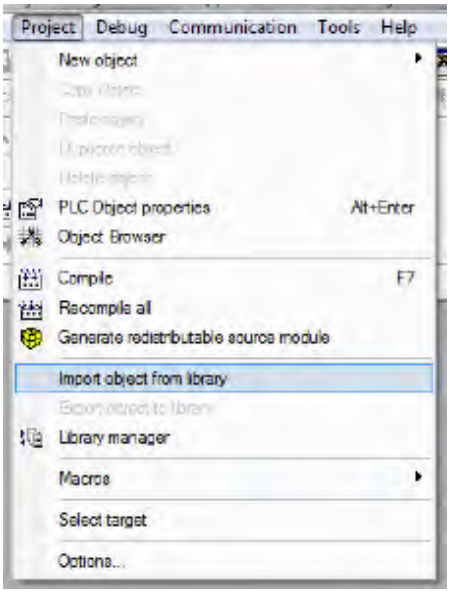
Delete objects	
Function	Allows you to delete an object.
Use	Select the object you want to delete, then press the *Delete object* button.

Multi selection

Multi selection is allowed for this mode, *Select all* and *Select none* buttons are visible.

5.5.1.3 USING OBJECT BROWSER FOR IMPORT

Object browser is also used to support objects importation in the project from a desired external library. Select *Import object from library* in the *Project* menu, then choose the desired library.



Available objects

In this mode you can list objects of these types:

- Programs.
- Function blocks.
- Functions.
- Variables.
- User types.

These items can be checked or unchecked in *Objects filter* section to show or to hide the objects of the chosen type in the list.

Other types of objects (Operators, Standard functions, Local variables, Basic types) cannot be imported so they are unchecked and disabled.

Available operations

Import objects is the only operation supported in this mode. It is possible to import selected objects by clicking on *Import objects* button or by double-clicking on one of the objects in the list.

Multi selection

Multi selection is allowed for this mode, *Select all* and *Select none* buttons are visible.

5.5.1.4 USING OBJECT BROWSER FOR OBJECT SELECTION

Object browser dialog is useful for many operations that requires the selection of a single PLC object. So Object browser can be used to select the program to add to a task, to select the type of a variable, to select an item to find in the project, etc..

Available objects

Available objects are strictly dependent on the context, for example in the program assignment to a task operation the only available objects are programs objects.

It is possible that not all available objects are selected by default.

Available operations

In this mode it is possible to select a single object by double-clicking on the list or by clicking on the *OK* button, then the dialog is automatically closed.

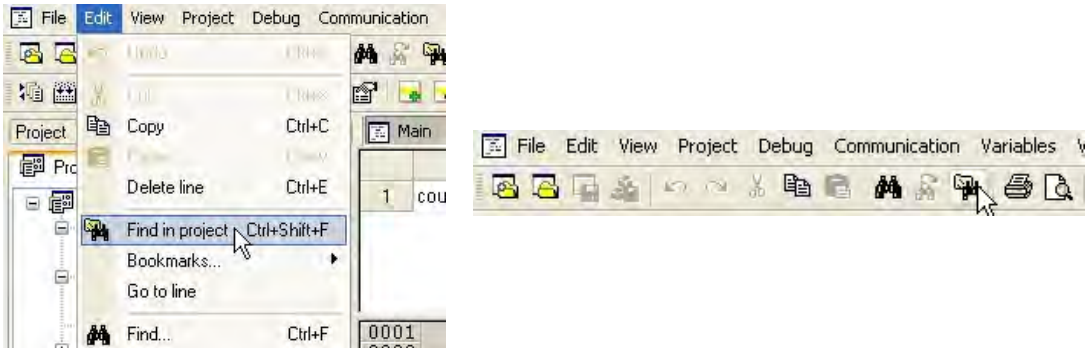
Multi selection

Multi selection is not allowed for this mode, *Select all* and *Select none* buttons are not visible.

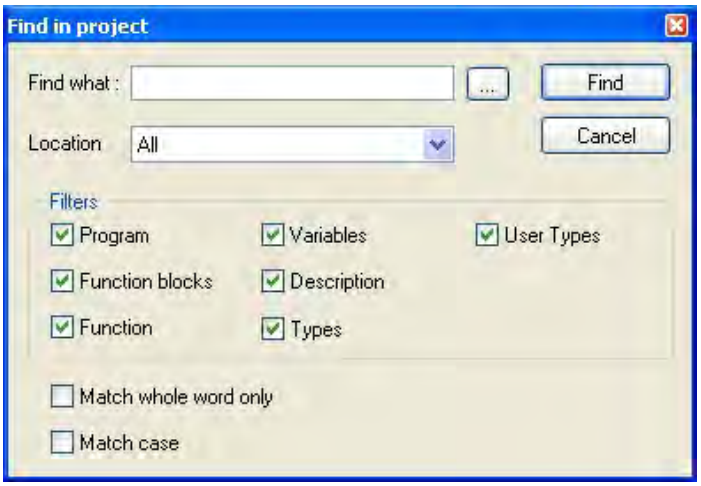
5.5.2 SEARCHING WITH THE FIND IN PROJECT COMMAND

The *Find in project* command retrieves all the instances of a specified character string in the project. Follow the procedure to use it correctly.

1) Click *Find in project*... in the *Edit* menu or in the *Main* toolbar.

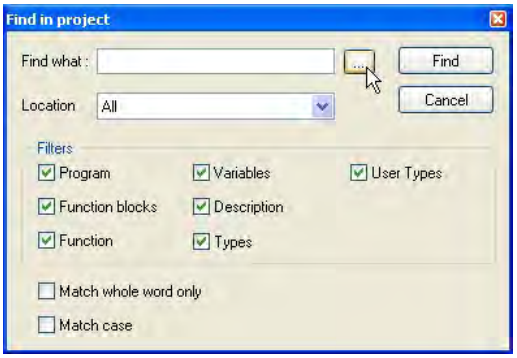


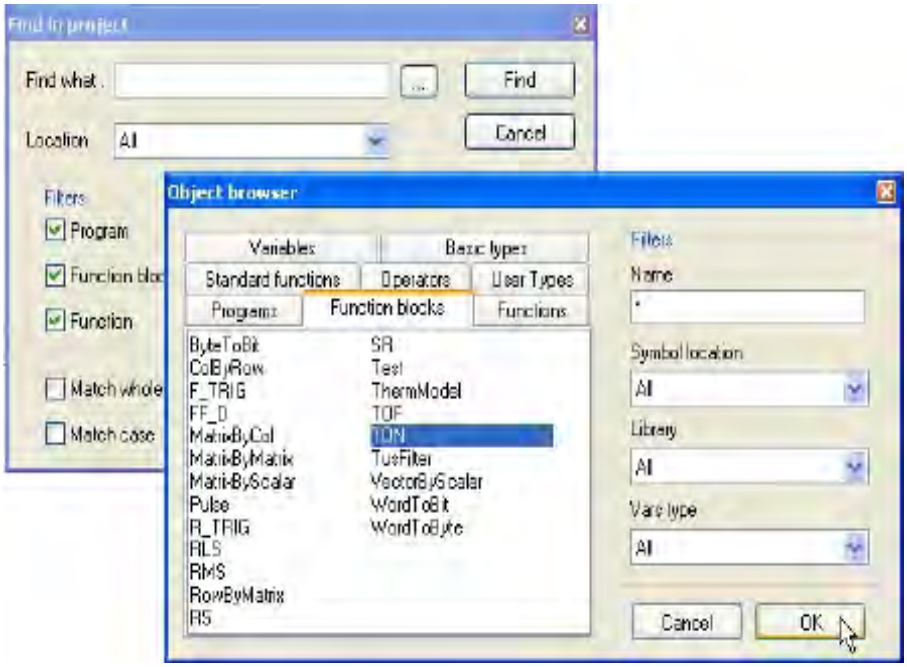
This causes the following dialog box to appear.



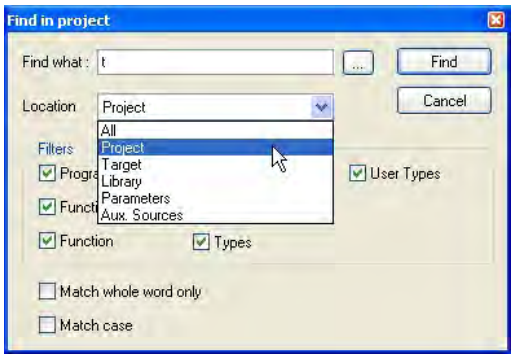
2) In the *Find what* text box, type the name of the object you want to look for.

Otherwise, click the *Browse* button to the right of the text box, and select the name of the object from the list of all the existing items.





3) Select one of the values listed in the *Location* combo box, so as to specify a constraint on the location of the objects to be inspected.

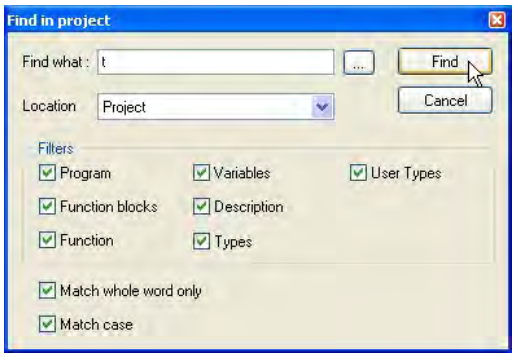


4) The frame named *Filters* contains 7 checkboxes, each of which, if ticked, enables research of the string among the object it refers to.

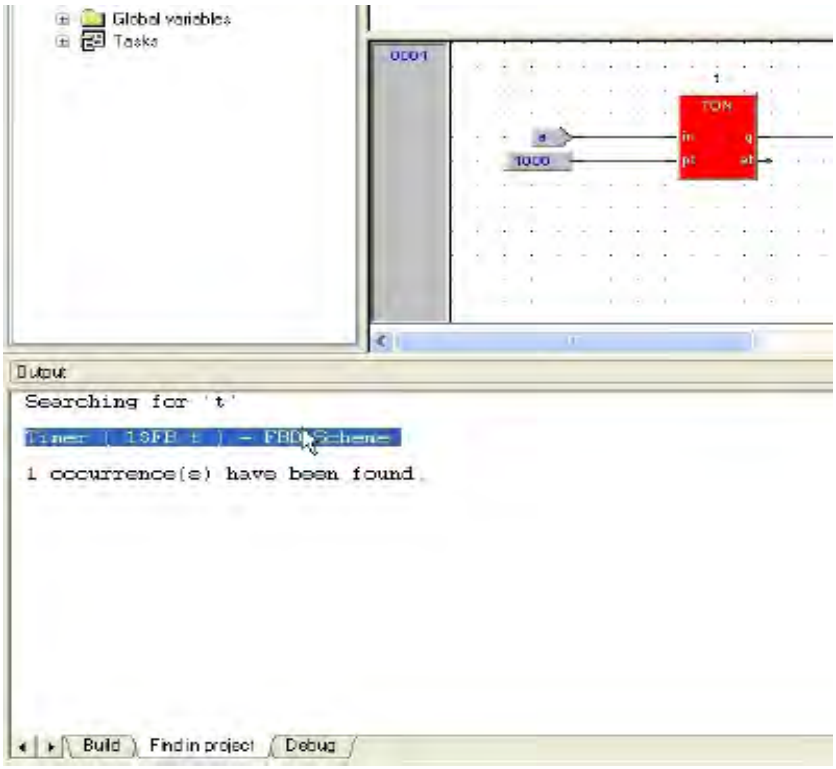
5) Tick *Match whole word only* if you want to compare your string to entire word only.

6) Tick *Match case* if you want your search to be case-sensitive.

7) Press *Find* to start the search, otherwise click *Cancel* to abandon.



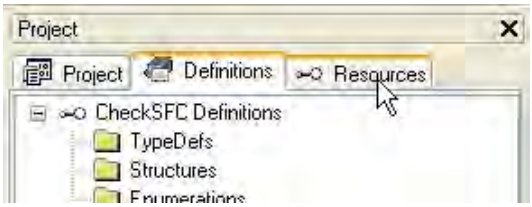
The results will be printed in the *Find in project* tab of the *Output* window.



5.6 WORKING WITH LOGICLAB EXTENSIONS

LogicLab's *Workspace* window may include a section whose contents completely depend on the target device the IDE is interfacing with: the *Resources* panel.

If the *Resources* panel is visible, you can access some additional features related to the target device (configuration elements, schemas, wizards, and so on).



Information about these features may be found in a separate document: refer to your hardware supplier for details.

6. EDITING THE SOURCE CODE

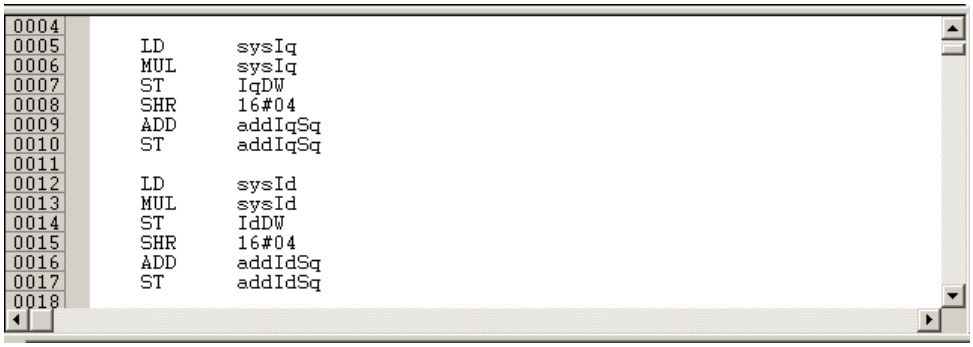
PLC editors

LogicLab includes five source code editors, which support the whole range of IEC 61131-3 programming languages: Instruction List (IL), Structured Text (ST), Ladder Diagram (LD), Function Block Diagram (FBD), and Sequential Function Chart (SFC).

Moreover, LogicLab includes a grid-like editor to support the user in the definition of variables.

This chapter focuses on all these editors.

6.1 INSTRUCTION LIST (IL) EDITOR



The IL editor allows you to code and modify POUs using IL (i.e., Instruction List), one of the IEC-compliant languages.

6.1.1 EDITING FUNCTIONS

The IL editor is endowed with functions common to most editors running on a Windows platform, namely:

- Text selection.
- *Cut*, *Copy*, and *Paste* operations.
- *Find and Replace* functions.
- Drag-and-drop of selected text.

Many of these functions are accessible through the *Edit* menu or through the *Main* toolbar.

6.1.2 REFERENCE TO PLC OBJECTS

If you need to add to your IL code a reference to an existing PLC object, you have two options:

- You can type directly the name of the PLC object.
- You can drag it to a suitable location. For example, global variables can be taken from the *Workspace* window, whereas standard operators and embedded functions can be dragged from the *Libraries* window, whereas local variables can be selected from the local variables editor.

6.1.3 AUTOMATIC ERROR LOCATION

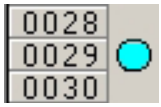
The IL editor also automatically displays the location of compiler errors. To know where a compiler error occurred, double-click the corresponding error line in the *Output* bar.

6.1.4 BOOKMARKS

You can set bookmarks to mark frequently accessed lines in your source file. Once a bookmark is set, you can use a keyboard command to move to it. You can remove a bookmark when you no longer need it.

6.1.4.1 SETTING A BOOKMARK

Move the insertion point to the line where you want to set a bookmark, then press *Ctrl+F2*. The line is marked in the margin by a light-blue circle.



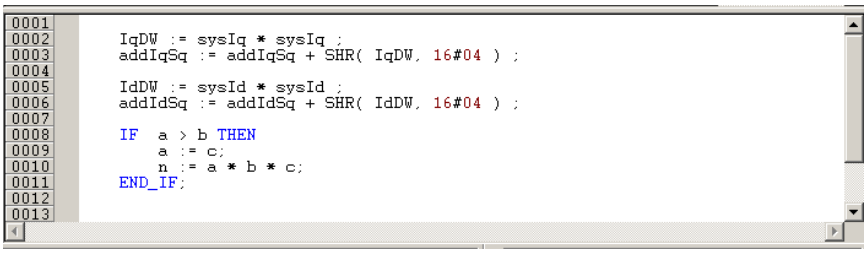
6.1.4.2 JUMPING TO A BOOKMARK

Press *F2* repeatedly, until you reach the desired line

6.1.4.3 REMOVING A BOOKMARK

Move the cursor to anywhere on the line containing the bookmark, then press *Ctrl+ F2*.

6.2 STRUCTURED TEXT (ST) EDITOR



The ST editor allows you to code and modify POUs using ST (i.e. Structured Text), one of the IEC-compliant languages.

6.2.1 CREATING AND EDITING ST OBJECTS

See the Creating and Editing POUs section (Paragraphs 5.1.1 and 5.1.2).

6.2.2 EDITING FUNCTIONS

The ST editor is endowed with functions common to most editors running on a Windows platform, namely:

- Text selection.
- *Cut*, *Copy*, and *Paste* operations.
- *Find and Replace* functions.
- Drag-and-drop of selected text.

Many of these functions are accessible through the *Edit* menu or through the *Main* toolbar.

6.2.3 REFERENCE TO PLC OBJECTS

If you need to add to your ST code a reference to an existing PLC object, you have two options:

- You can type directly the name of the PLC object.
- You can drag it to a suitable location. For example, global variables can be taken from the *Workspace* window, whereas embedded functions can be dragged from the *Libraries* window, whereas local variables can be selected from the local variables editor.

6.2.4 AUTOMATIC ERROR LOCATION

The ST editor also automatically displays the location of compiler errors. To know where a compiler error has occurred, double-click the corresponding error line in the *Output* bar.

6.2.5 BOOKMARKS

You can set bookmarks to mark frequently accessed lines in your source file. Once a bookmark is set, you can use a keyboard command to move to it. You can remove a bookmark when you no longer need it.

6.2.5.1 SETTING A BOOKMARK

Move the insertion point to the line where you want to set a bookmark, then press *Ctrl+F2*. The line is marked in the margin by a light-blue circle.

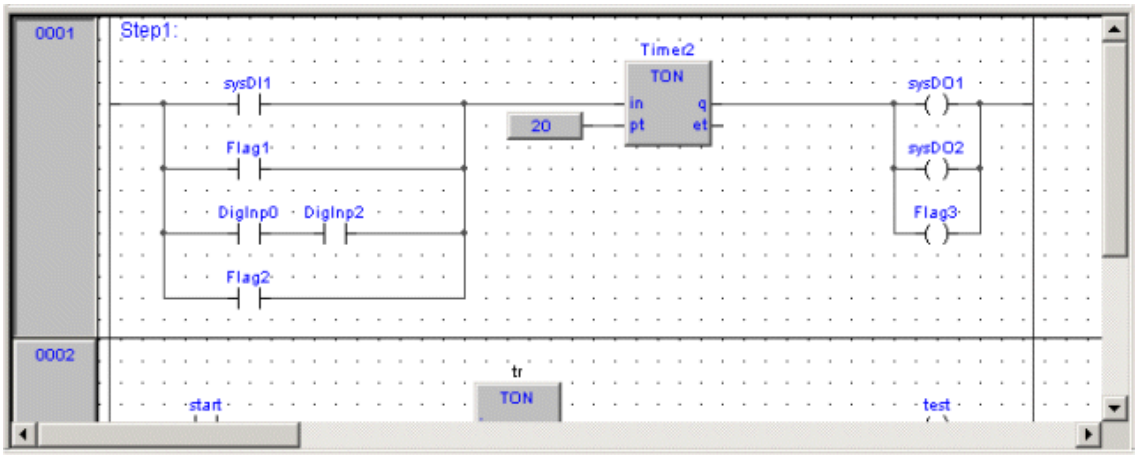
6.2.5.2 JUMPING TO A BOOKMARK

Press *F2* repeatedly, until you reach the desired line.

6.2.5.3 REMOVING A BOOKMARK

Move the cursor to anywhere on the line containing the bookmark, then press *Ctrl+F2*.

6.3 LADDER DIAGRAM (LD) EDITOR



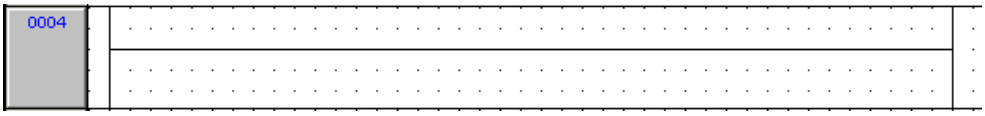
The LD editor allows you to code and modify POUs using LD (i.e. Ladder Diagram), one of the IEC-compliant languages.

6.3.1 CREATING A NEW LD DOCUMENT

See the Creating and Editing POUs section (Paragraphs 5.1.1 and 5.1.2).

6.3.2 ADDING/REMOVING NETWORKS

Every POU coded in LD consists of a sequence of networks. A network is defined as a maximal set of interconnected graphic elements. The upper and lower bounds of every network are fixed by two straight lines, while each network is delimited on the left by a grey raised button containing the network number.



On each LD network the right and the left power rail are represented, according to the LD language indication.

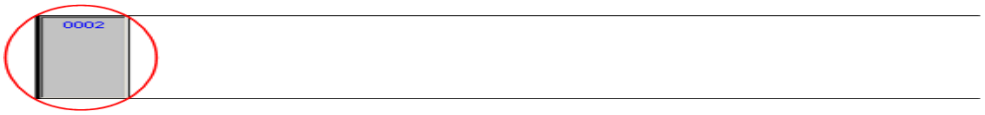
On the new LD network a horizontal line links the two power rails. It is called the “power link”. On this link, all the LD elements (contacts, coils and blocks) are to be placed.

You can perform the following operations on networks:

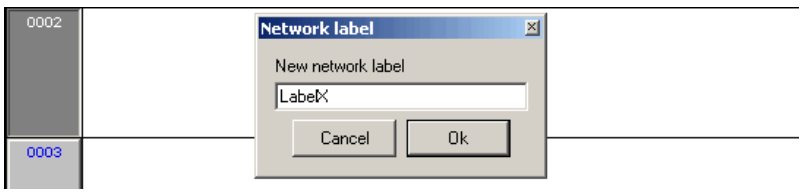
- To add a new blank network, click *Network>New* in the *Scheme* menu, or press one of the equivalent buttons in the *Network* toolbar.
- To assign a label to a selected network, give the *Network>Label* command from the *Scheme* menu. This enables jumping to the labeled network.
- To display a background grid which helps you to align objects, press *View grid* in the *Network* toolbar.
- To add a comment, press the *Comment* button in the *FBD* toolbar.

6.3.3 LABELING NETWORKS

You can modify the usual order of execution of networks through a jump statement, which transfers the program control to a labeled network. To assign a label to a network, double-click the raised grey button on the left, which bears the network number.



This causes a dialog box to appear, where you can type the label you want to associate with the selected network.

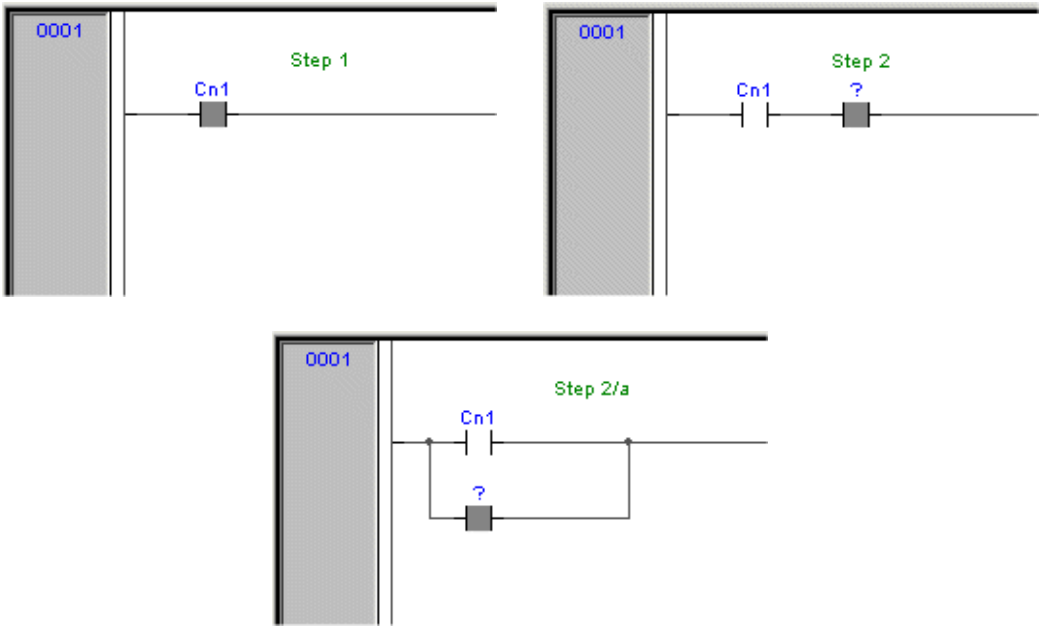


If you press *OK*, the label is printed in the top left-hand corner of the selected network.

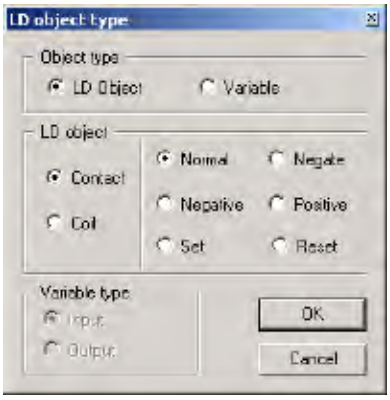
6.3.4 INSERTING CONTACTS

To insert new contacts on the network apply one of the following options:

- Select a contact, a block or a connection. Select the insertion mode between serial or parallel (using the button on the *LD* toolbar or the *Scheme* menu). Insert the appropriate contact (using the button on the *LD* toolbar, the *Scheme>Object>New* or the pop-up menu option). For serial insertion, the new contact will be inserted on the right side of the selected contact/block or in the middle of the selected connection depending on the element selected before the insertion. For parallel insertions, several contacts/blocks can be selected before performing the insertion. The new contact will be inserted at the endpoints of the selection block.



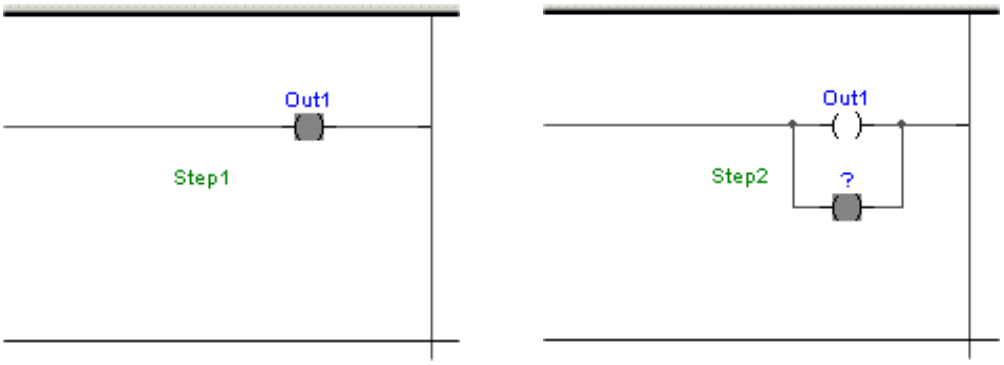
- Drag a boolean variable to the desired place over a connection. For example, global variables can be taken from the *Workspace* window, whereas local variables can be selected from the local variables editor. The dialog box shown below will appear, requesting to define whether the variable should be inserted as a contact, coil or variable (like FBD schemes). Choose the appropriate contact type. Contacts inserted with drag and drop will always be inserted in series.



6.3.5 INSERTING COILS

To insert new coils on the network apply one of the following options:

- Press one of the coil buttons in the *LD* toolbar. The new coil will be inserted and linked to the right power rail. If other coils are already present in the network, the new coil will be added in parallel with the previous ones.



- Drag a boolean variable on the network. For example, global variables can be taken from the *Workspace* window, whereas local variables can be selected from the local variables editor. A dialog box will appear, requesting to indicate whether the variable should be inserted as a contact, coil or variable. Choose the appropriate coil type.

6.3.6 INSERTING BLOCKS

Operators, functions and function blocks can be inserted into an LD network in the following modes:

- On the power link, as contacts and coils.
- Outside the power link (to do so, follow the indications as for the FBD blocks).

To insert blocks on the network apply one of the following options:

- Select a contact, connection or block then click *Object>New* in the *Scheme* menu.
- Select a contact, connection or block, then press the *New block* button in the *FBD* toolbar, which causes a dialog box to appear listing all the objects of the project, then choose one item from the list. If the block is a constant, a return statement, or a jump statement, you can directly press the relevant buttons in the *FBD* toolbar.
- Drag the selected object (from the *Workspace* window, the *Libraries* window or the local variables editor) over the desired connection.

The two upper pins will be connected to the power link. The *EN/ENO* pins should be activated before the insertion.

6.3.7 EDITING COILS AND CONTACTS PROPERTIES

The type of a contact (normal, negated) or a coil (normal, negated, set, reset) can be changed by one of the following operations:

- Double-click on the element (contact or coil).
- Select the element and then press the *Enter* key.
- Select the element, activate the pop-up menu with the right mouse button, then select *Properties*.

An apposite dialog box will appear. Select the desired element type from the list presented and then press *OK*.

6.3.8 EDITING NETWORKS

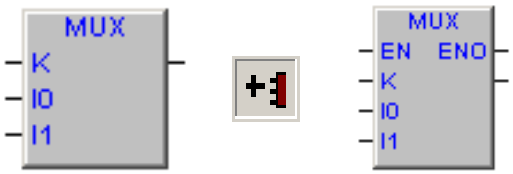
The LD editor is endowed with functions common to most graphic applications running on a Windows platform, namely:

- Selection of a block.
- Selection of a set of blocks by pressing *Shift+Right* button and by drawing a frame including the blocks to select.
- *Cut*, *Copy*, and *Paste* operations of a single block as well as of a set of blocks.
- Drag-and-drop.

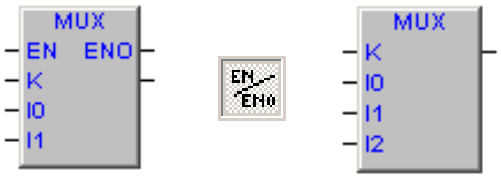
All the mentioned functions are accessible through the *Edit* menu or through the *Main* toolbar.

6.3.9 MODIFYING PROPERTIES OF BLOCKS

- Click *Increment pins +* in the *Scheme* menu, or press the *Inc pins* button in the *FBD* toolbar, to increment the number of input pins of some operators and embedded functions.



- Click *Enable EN/ENO* pins in the *Scheme* menu, or press the *EN/ENO* button in the *FBD* toolbar, to display the enable input and output pins.



- Click *Object . Instance name* in the *Scheme* menu, or press the *FBD properties* button in the *FBD* toolbar, to change the name of an instance of a function block.

6.3.10 GETTING INFORMATION ON A BLOCK

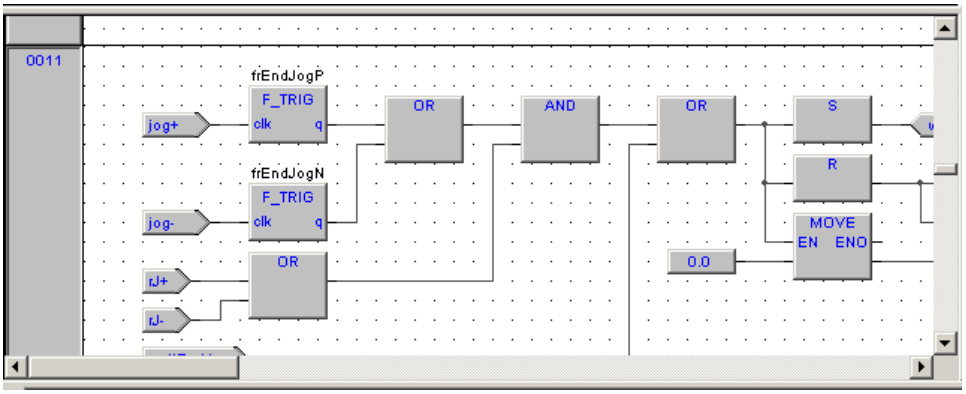
You can always get information on a block that you added to an LD document, by selecting it and then performing one of the following operations:

- Click *Object>Open source* in the *Scheme* menu, or press the *View source* button in the *FBD* toolbar, to open the source code of a block.
- Click *Object properties* in the *Scheme* menu, or press the *FBD properties* button in the *FBD* toolbar, to see properties and input/output pins of the selected block.

6.3.11 AUTOMATIC ERROR RETRIEVAL

The LD editor also automatically displays the location of compiler errors. To reach the block where a compiler error occurred, double-click the corresponding error line in the Output bar.

6.4 FUNCTION BLOCK DIAGRAM (FBD) EDITOR



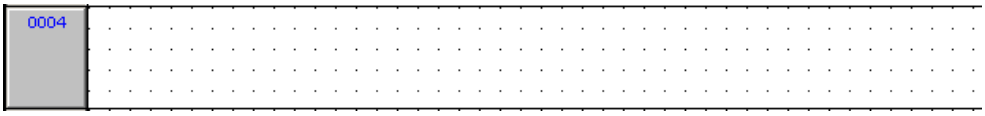
The FBD editor allows you to code and modify POUs using FBD (i.e. Function Block Diagram), one of the IEC-compliant languages.

6.4.1 CREATING A NEW FBD DOCUMENT

See the Creating and editing POUs section (Paragraphs 5.1.1 and 5.1.2).

6.4.2 ADDING/REMOVING NETWORKS

Every POU coded in FBD consists of a sequence of networks. A network is defined as a maximal set of interconnected graphic elements. The upper and lower bounds of every network are fixed by two straight lines, while each network is delimited on the left by a grey raised button containing the network number.

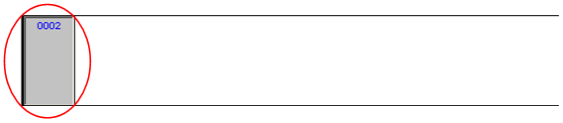


You can perform the following operations on networks:

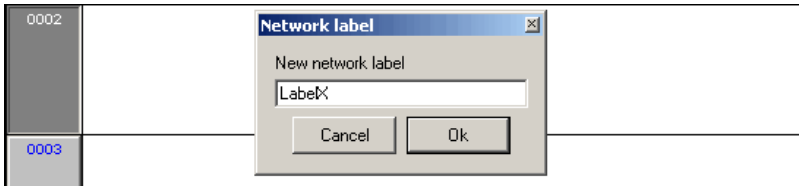
- To add a new blank network, click *Network>New* in the *Scheme* menu, or press one of the equivalent buttons in the *Network* toolbar.
- To assign a label to a selected network, give the *Network>Label* command from the *Scheme* menu. This enables jumping to the labeled network.
- To display a background grid which helps you to align objects, press *View grid* in the *Network* toolbar.
- To add a comment, press the *Comment* button in the FBD toolbar.

6.4.3 LABELING NETWORKS

You can modify the usual order of execution of networks through a jump statement, which transfers the program control to a labeled network. To assign a label to a network, double-click the raised grey button on the left, that bears the network number.



This causes a dialog box to appear, which lets you type the label you want to associate with the selected network.



If you press *OK*, the label is printed in the top left-hand corner of the selected network.

6.4.4 INSERTING AND CONNECTING BLOCKS

This paragraph shows you how to build a network.

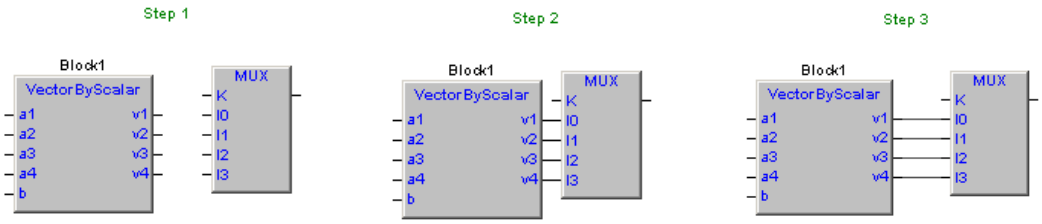
Add a block to the blank network, by applying one of the following options:

- Click *Object>New* in the *Scheme* menu.
- Press the *New block* button in the *FBD* toolbar, which causes a dialog box to appear listing all the objects of the project, then choose one item from the list. If the block is a constant, a return statement, or a jump statement, you can directly press the relevant buttons in the *FBD* toolbar.
- Drag the selected object to the suitable location. For example, global variables can be taken from the *Workspace* window, whereas standard operators and embedded functions can be dragged from the *Libraries* window, whereas local variables can be selected from the local variables editor.

Repeat until you have added all the blocks that will make up the network.

Then connect blocks:

- Click *Connection mode* in the *Edit* menu, or press the *Connection* button in the *FBD* toolbar, or simply press the space bar of your keyboard. Click once the source pin, then move the mouse pointer to the destination pin: the FBD editor draws a logical wire from the former to the latter.
- If you want to connect two blocks having a one-to-one correspondence of pins, you can enable the autoconnection mode by clicking *Autoconnect* in the *Scheme* menu, or by pressing the *Autoconnect* button in the *Network* toolbar. Then take the two blocks, drag them close to each other so as to let the corresponding pins coincide. The FBD editor automatically draws the logical wires.



If you delete a block, its connections are not removed automatically, but they become invalid and they are redrawn red. Click *Delete invalid connection* in the *Scheme* menu, or type *Ctrl+B* on your keyboard.

6.4.5 EDITING NETWORKS

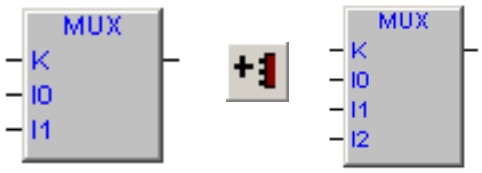
The FBD editor is endowed with functions common to most graphic applications running on a Windows platform, namely:

- Selection of a block.
- Selection of a set of blocks by pressing *Shift* + left button and by drawing a frame including the blocks to select.
- *Cut*, *Copy* and *Paste* operations of a single block as well as of a set of blocks.
- Drag-and-drop.

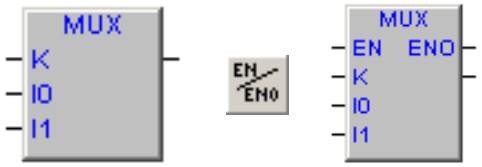
All the mentioned functions are accessible through the *Edit* menu or through the *Main* toolbar.

6.4.6 MODIFYING PROPERTIES OF BLOCKS

- Click *Increment pins* + in the *Scheme* menu, or press the *Inc pins* button in the *FBD* toolbar, to increment the number of input pins of some operators and embedded functions.



- Click *Enable EN/ENO pins* in the *Scheme* menu, or press the *EN/ENO* button in the FBD toolbar, to display the enable input and output pins.



- Click *Object>Instance name* in the *Scheme* menu, or press the *FBD properties* button in the *FBD* toolbar, to change the name of an instance of a function block.

6.4.7 GETTING INFORMATION ON A BLOCK

You can always get information on a block that you added to an FBD document, by selecting it and then performing one of the following operations:

- Click *Object> Open source* in the *Scheme* menu, or press the *View source* button in the *FBD* toolbar, to open the source code of a block.
- Click *Object properties* in the *Scheme* menu, or press the *FBD properties* button in the *FBD* toolbar, to see properties and input/output pins of the selected block.

6.4.8 AUTOMATIC ERROR RETRIEVAL

The FBD editor also automatically displays the location of compiler errors. To reach the block where a compiler error occurred, double-click the corresponding error line in the *Output* bar.

6.5 SEQUENTIAL FUNCTION CHART (SFC) EDITOR

The SFC editor allows you to code and modify POUs using SFC (i.e. Sequential Function Chart), one of the IEC-compliant languages.

6.5.1 CREATING A NEW SFC DOCUMENT

See the creating and editing POUs section (Paragraphs 5.1.1 and 5.1.2).

6.5.2 INSERTING A NEW SFC ELEMENT

You can apply indifferently one of the following procedures:

- Click *Object>New* in the *Scheme* menu, then select the type of the new element (action, transition, or jump).
- Press the *New step*, *Add Transition* or *Add Jump* button in the *SFC* toolbar.

In either case, the mouse pointer changes to:

for steps;

for transitions;

for jumps.

6.5.3 CONNECTING SFC ELEMENTS

Follow this procedure to connect SFC blocks:

- Click *Connection mode* in the *Edit* menu, or press the *Connection* button in the *FBD* toolbar, or simply press the space bar on your keyboard. Click once the source pin, then move the mouse pointer to the destination pin: the SFC editor draws a logical wire from the former to the latter.
- Alternatively, you can enable the autoconnection mode by clicking *Autoconnect* in the *Scheme* menu, or by pressing the *Autoconnect* button in the *Network* toolbar. Then take the two blocks, and drag them close to each other so as to let the respective pins coincide, which makes the SFC editor draw automatically the logical wire.

6.5.4 ASSIGNING AN ACTION TO A STEP

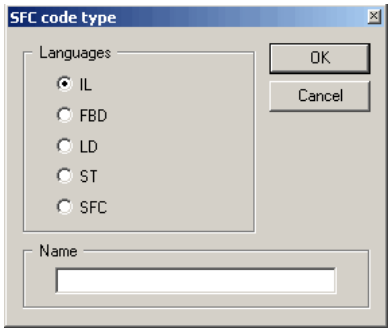
This paragraph explains how to implement an action and how to assign it to a step.

6.5.4.1 WRITING THE CODE OF AN ACTION

To start implementing an action, you need to open an editor. Do it by applying one of the following procedures:

- Click *Code object>New action* in the *Scheme* menu.
- Right-click on the name of the SFC POU in the *Workspace* window. A context menu appears, from which you can select the *New Action* command.

In either case, LogicLab displays a dialog box like the one shown below.



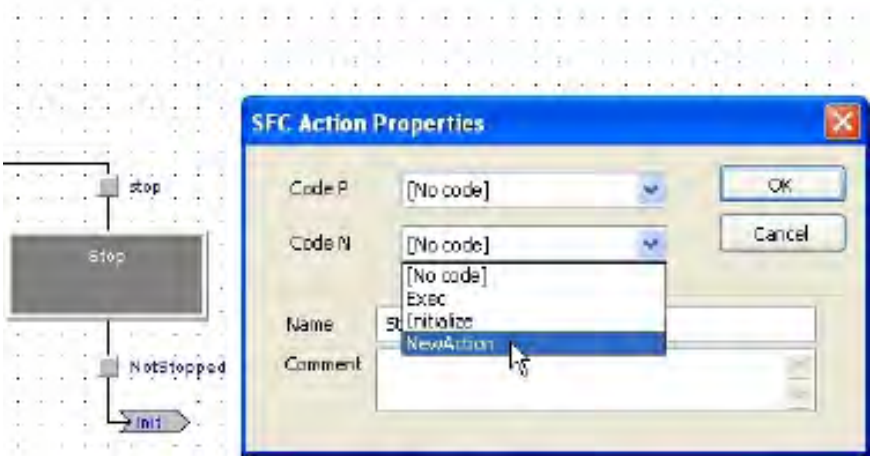
Select one of the languages and type the name of the new action in the text box at the bottom of the dialog box. Then either confirm by pressing *OK*, or quit by clicking *Cancel*.

If you press *OK*, LogicLab opens automatically the editor associated with the language you selected in the previous dialog box and you are ready to type the code of the new action.

Note that you are not allowed to declare new local variables, as the module you are now editing is a component of the original SFC module, which is the POU where local variables can be declared. The scope of local variables extends to all the actions and transitions making up the SFC diagram.

6.5.4.2 ASSIGNING AN ACTION TO A STEP

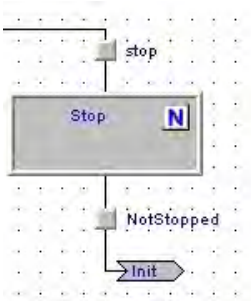
When you have finished writing the code, double-click the step you want to assign the new action to. This causes the following dialog box to appear.



From the list shown in the *Code N* box, select the name of the action you want to execute if the step is active. You may also choose, from the list shown in the *Code P* (*Pulse*) box, the name of the action you want to execute each time the step becomes active (that is, the action is executed only once per step activation, regardless of the number of cycles the step remains active). Confirm the assignments by pressing *OK*.

In the SFC schema, action to step assignments are represented by letters on the step block:

- action *N* by letter N in the top right corner;
- action *P* by letter P in the bottom right corner.

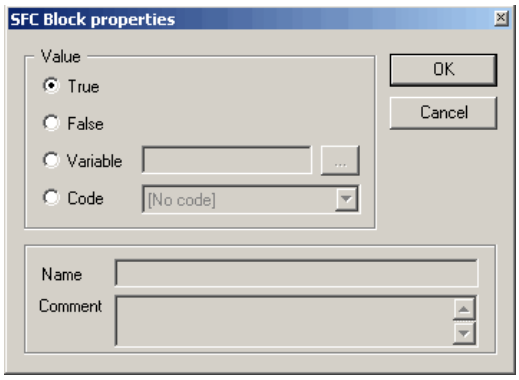


If later you need to edit the source code of the action, you can just double-click these letters. Alternatively, you can double-click the name of the action in the *Actions* folder of the *Workspace* window.

6.5.5 SPECIFYING A CONSTANT/A VARIABLE AS THE CONDITION OF A TRANSITION

As stated in the relevant section of the language reference, a transition condition can be assigned through a constant, a variable, or a piece of code. This paragraph explains how to use the first two means, while conditional code is discussed in the next paragraph.

First of all double-click the transition you want to assign a condition to. This causes the following dialog box to appear.



Select *True* if you want this transition to be constantly cleared, *False* if you want the PLC program to keep executing the preceding block.

Instead, if you select *Variable* the transition will depend on the value of a Boolean variable. Click the corresponding bullet, to make the text box to its right available, and to specify the name of the variable.

To this purpose, you can also make use of the objects browser, that you can invoke by pressing the *Browse* button shown here below.

Click *OK* to confirm, or *Cancel* to quit without applying changes.

6.5.6 ASSIGNING CONDITIONAL CODE TO A TRANSITION

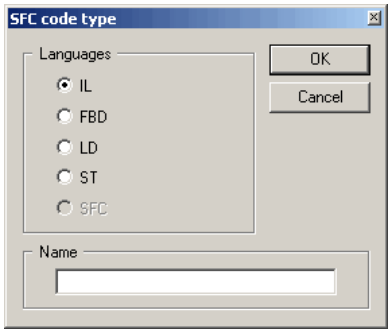
This paragraph explains how to specify a condition through a piece of code, and how to assign it to a transition.

6.5.6.1 WRITING THE CODE OF A CONDITION

Start by opening an editor, following one of these procedures:

- Click *Code object>New transition* in the *Scheme* menu.
- Right-click on the name of the SFC POU in the *Workspace* window, then select the *New transition* command from the context menu that appears.

In either case, LogicLab displays a dialog box similar the one shown in the following picture.



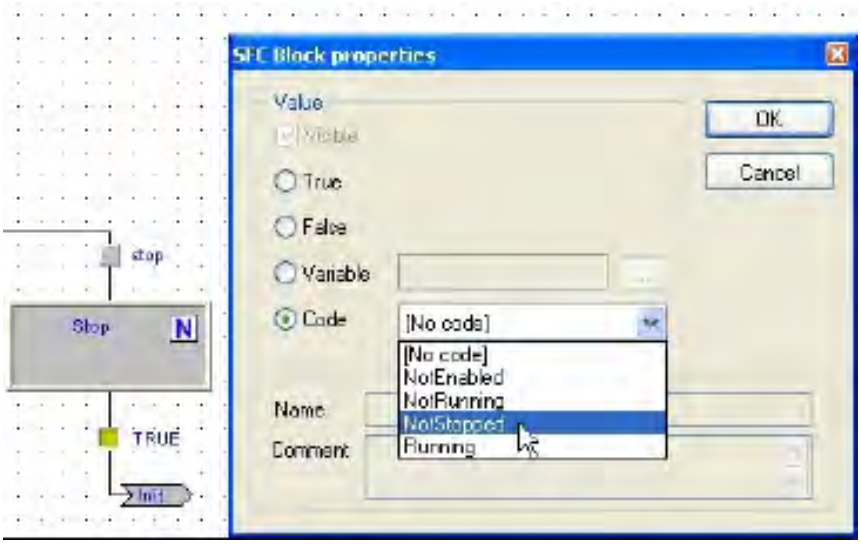
Note that you can use any language except SFC to code a condition. Select one of the languages and type the name of the new condition in the text box at the bottom of the dialog box. Then either confirm by pressing *OK*, or quit by clicking *Cancel*.

If you press OK, LogicLab opens automatically the editor associated with the language you selected in the previous dialog box and you can type the code of the new condition.

Note that you are not allowed to declare new local variables, as the module you are now editing is a component of the original SFC module, which is the POU where local variables can be declared. The scope of local variables extends to all the actions and transitions making up the SFC diagram.

6.5.6.2 ASSIGNING A CONDITION TO A TRANSITION

When you have finished writing the code, double-click the transition you want to assign the new condition to. This causes the following dialog box to appear.



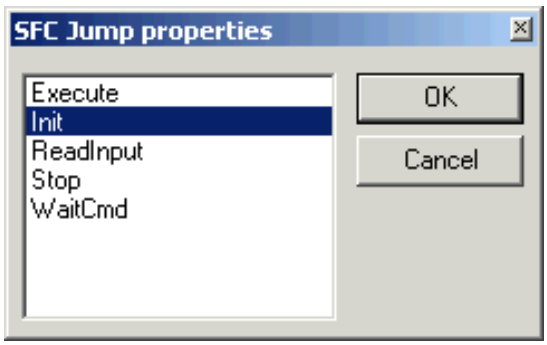
Select the name of the condition you want to assign to this step. Then confirm by pressing *OK*.

If later you need to edit the source code of the condition, you can double-click the name

of the transition in the *Transitions* folder of the *Workspace* window.

6.5.7 SPECIFYING THE DESTINATION OF A JUMP

To specify the destination step of a jump, double-click the jump block in the *Chart* area. This causes the dialog box shown below to appear, listing the name of all the existing steps. Select the destination step, then either press *OK* to confirm or *Cancel* to quit.



6.5.8 EDITING SFC NETWORKS

The SFC editor is endowed with functions common to most graphic applications running on a Windows platform, namely:

- Selection of a block.
- Selection of a set of blocks by pressing *Ctrl* + left button.
- *Cut*, *Copy*, and *Paste* operations of a single block as well as of a set of blocks.
- Drag-and-drop.

Some of these functions are accessible through the *Edit* menu or through the *Main* toolbar.

6.6 VARIABLES EDITOR

LogicLab includes a graphical editor for both global and local variables that supplies a user-friendly interface for declaring and editing variables: the tool takes care of the translation of the contents of these editors into syntactically correct IEC 61131-3 source code.

As an example, consider the contents of the Global variables editor represented in the following figure.

	Name	Type	Address	Group	Array	Init value	Attribute
9	gA	BOOL	Auto		No	TRUE	..
10	gB	REAL	Auto		[0..4]	5(0)	..
11	gC	REAL	%MD60.20		No	1.0	..
12	gD	INT	Auto		No	-74	CONSTANT

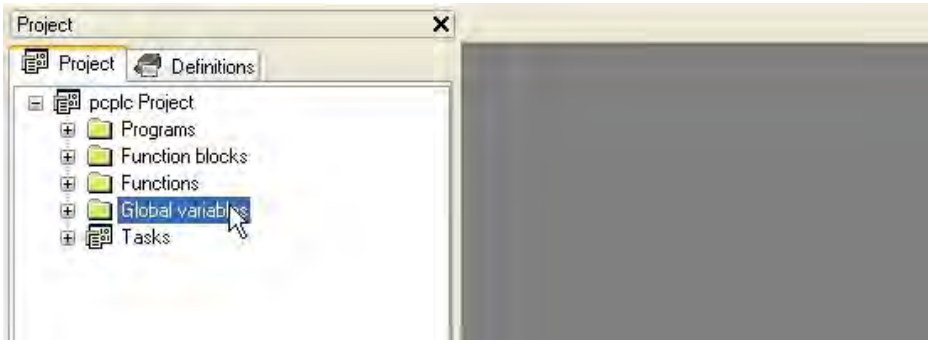
The corresponding source code will look like this:

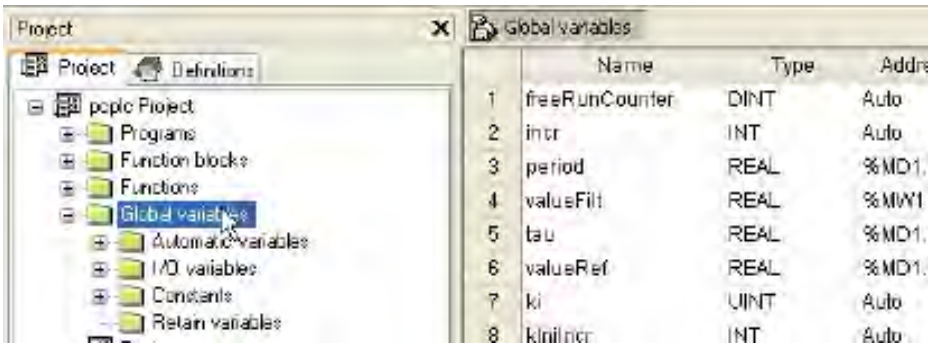
```
VAR_GLOBAL
    gA : BOOL := TRUE;
    gB : ARRAY[ 0..4 ] OF REAL;
    gC AT %MD60.20 : REAL := 1.0;
    END_VAR
    VAR_GLOBAL CONSTANT
    gD : INT := -74;
    END_VAR
```

6.6.1 OPENING A VARIABLES EDITOR

6.6.1.1 OPENING THE GLOBAL VARIABLES EDITOR

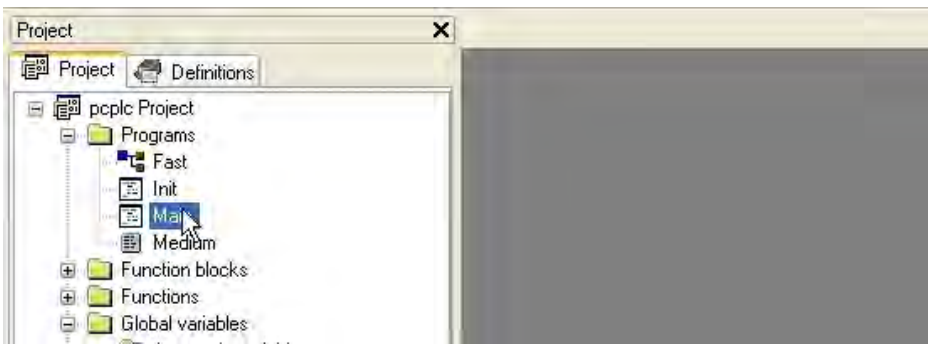
In order to open the Global variables editor, double-click on *Global variables* in the project tree.

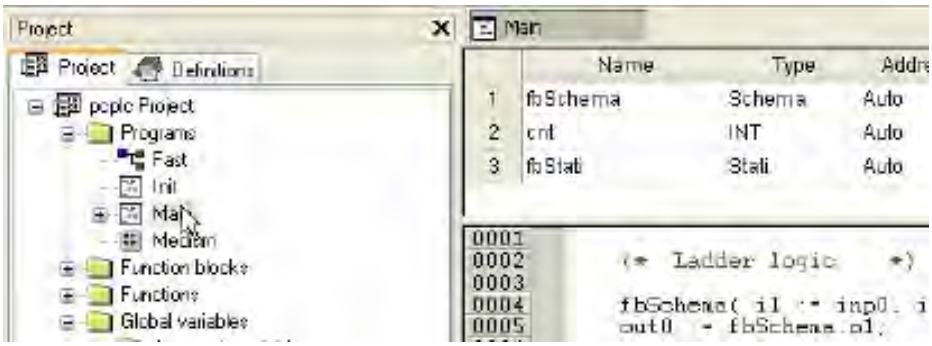




6.6.1.2 OPENING A LOCAL VARIABLES EDITOR

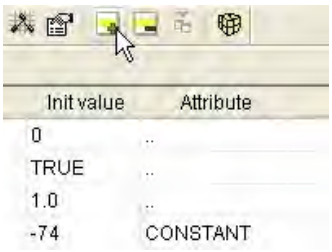
To open a local variables editor, just open the Program Organization Unit the variables you want to edit are local to.



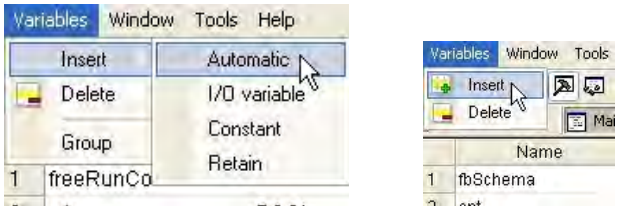


6.6.2 CREATING A NEW VARIABLE

In order to create a new variable, you may click on the *Insert record* item in the *Project* toolbar.



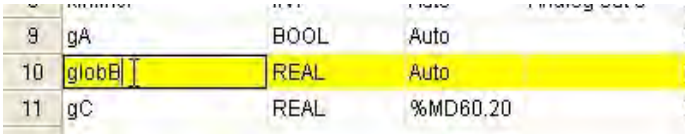
Alternatively, you may access the *Variables* menu and choose *Insert*.



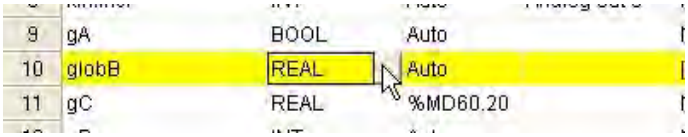
6.6.3 EDITING VARIABLES

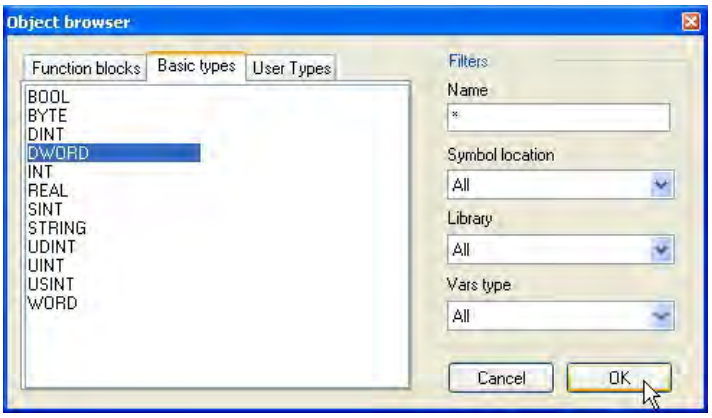
Follow this procedure to edit the declaration of a variable in a variables editor (all the following steps are optional and you will typically skip most of them when editing a variable):

1) Edit the name of the variable by entering the new name in the corresponding cell.

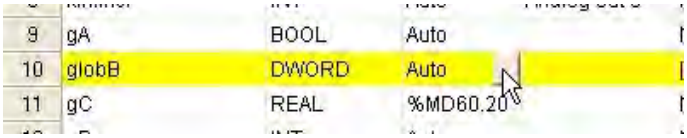


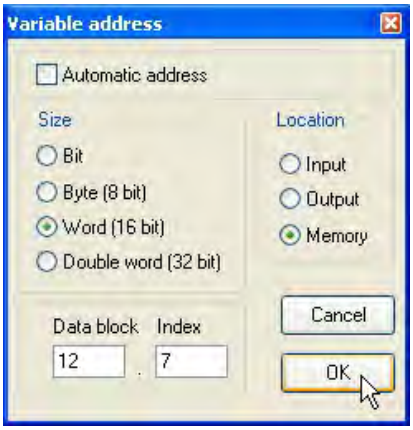
2) Change the variable type, either by editing the type name in the corresponding cell or by clicking on the button in that cell and select the desired type from the list that pops up.





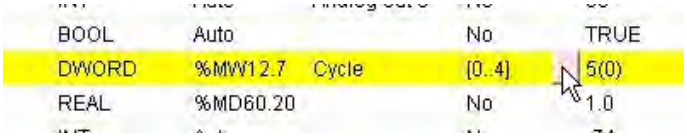
3) Edit the address of the variable by clicking on the button in the corresponding cell and entering the required information in the window that shows up. Note that, in the case of global variables, this operation may change the position of the variable in the project tree.

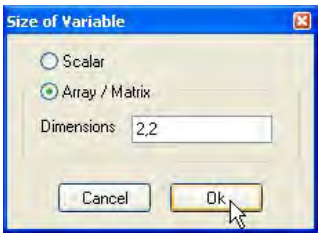




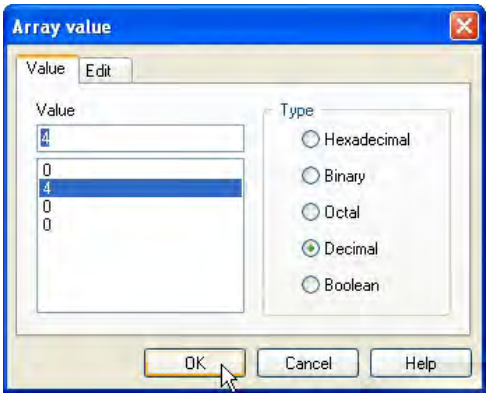
4) In the case of global variables, you can assign the variable to a group, by selecting it from the list which opens when you click on the corresponding cell. This operation will change the position of the variable in the project tree.

5) Choose whether a variable is an array or not; if it is, edit the size of the variable.

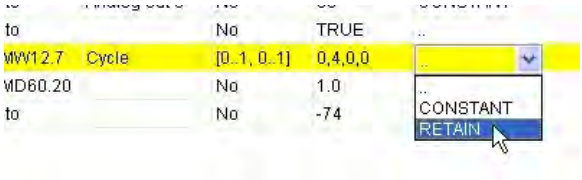




6) Edit the initial values of the variable: click on the button in the corresponding cell and enter the values in the window that pops up.



7) Assign an attribute to the variable (for example, `CONSTANT` or `RETAIN`), by selecting it from the list which opens when you click on the corresponding cell.

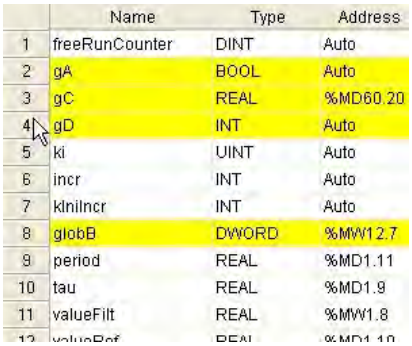


8) Type a description for the variable in the corresponding cell. Note that, in the case of global variables, this operation may change the position of the variable in the project tree.

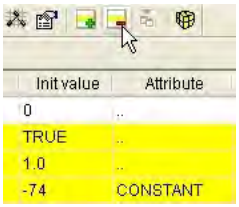
9) Save the project to persist the changes you made to the declaration of the variable.

6.6.4 DELETING VARIABLES

In order to delete one or more variables, select them in the editor: you may use the *CTRL* or the *SHIFT* keys to select multiple elements.

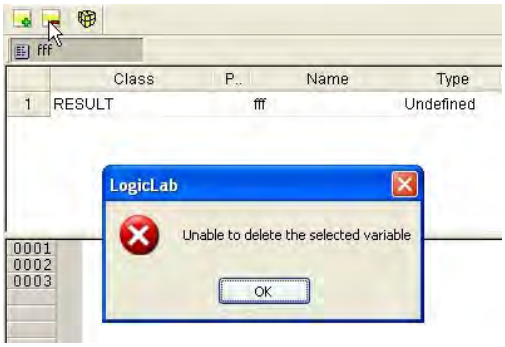


Then, click on the *Delete* record in the *Project* toolbar.



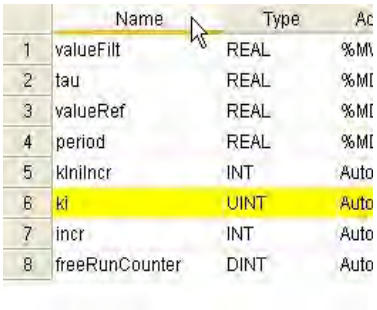
Alternatively, you may access the *Variables* menu and choose *Delete*.

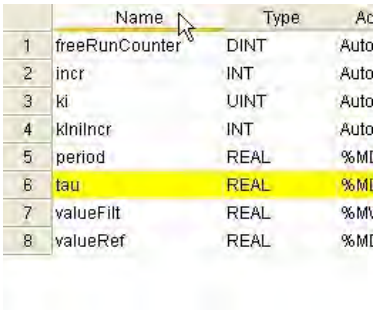
Notice that you cannot delete the RESULT of an IEC61131-3 FUNCTION.



6.6.5 SORTING VARIABLES

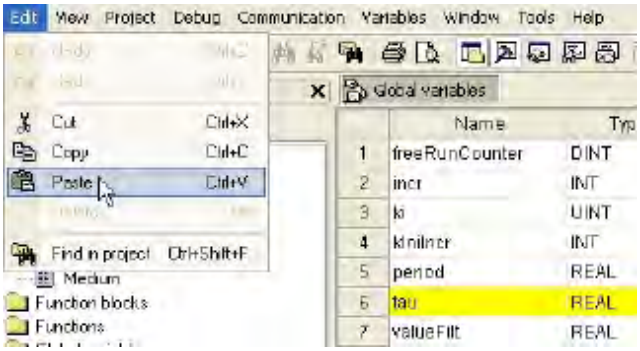
You can sort the variables in the editor by clicking on the column header of the field you want to use as the sorting criterion.

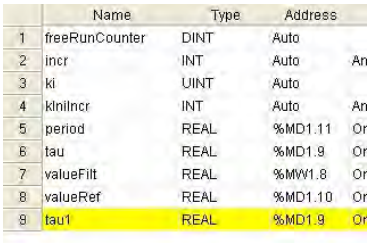




6.6.6 COPYING VARIABLES

The variables editor allows you to quickly copy and paste elements. You can either use keyboard shortcuts or the *Edit* menu to access these features.





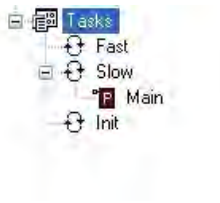
	Name	Type	Address	
1	freeRunCounter	DINT	Auto	
2	incr	INT	Auto	An
3	ki	UINT	Auto	
4	klnilncr	INT	Auto	An
5	period	REAL	%MD1.11	Or
6	tau	REAL	%MD1.9	Or
7	valueFilt	REAL	%MW1.8	Or
8	valueRef	REAL	%MD1.10	Or
9	tau1	REAL	%MD1.9	Or

7. COMPILING

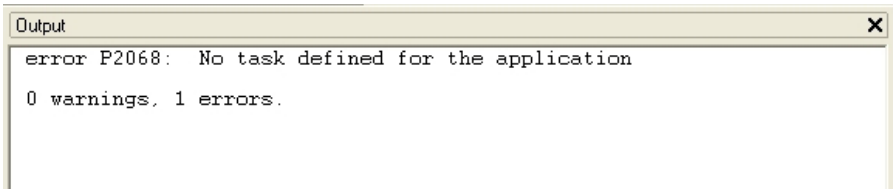
Compilation consists of taking the PLC source code and automatically translating it into binary code, which can be executed by the processor on the target device.

7.1 COMPILING THE PROJECT

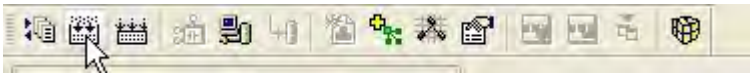
Before starting actual compilation, make sure that at least one program has been assigned to a task.



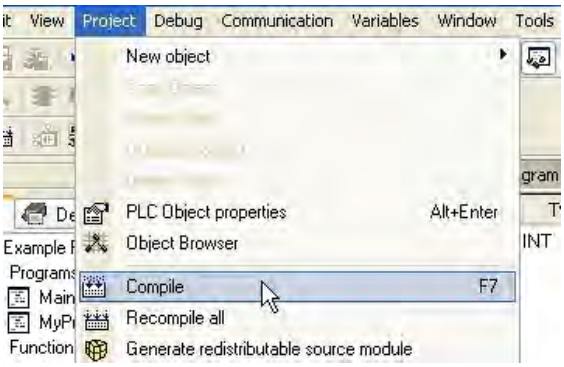
When this pre-condition does not hold, compilation aborts with a meaningful error message.



In order to start compilation, click the *Compile* button in the *Project* toolbar.



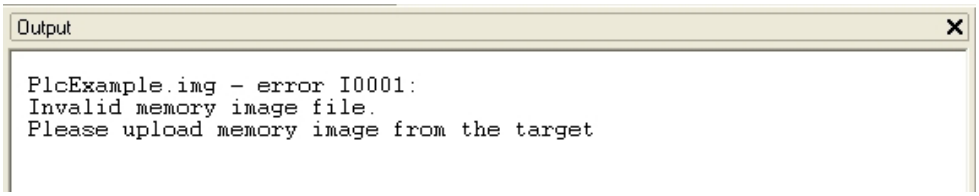
Alternatively, you can choose *Compile* from the *Project* menu or press *F7* on your keyboard.



Note that LogicLab automatically saves all changes to the project before starting the compilation.

7.1.1 IMAGE FILE LOADING

Before performing the actual compilation, the compiler needs to load the image file (*img file*), which contains the map of memory of the target device. If the target is connected when compilation is started, the compiler seeks the image file directly on the target. Otherwise, it loads the local copy of the image file from the working folder. If the target device is disconnected and there is no local copy of the image file, compilation cannot be carried out: you are then required to connect to a working target device.



7.2 COMPILER OUTPUT

If the previous step was accomplished, the compiler performs the actual compilation, then prints a report in the *Output* bar. The last string of the report has the following format:

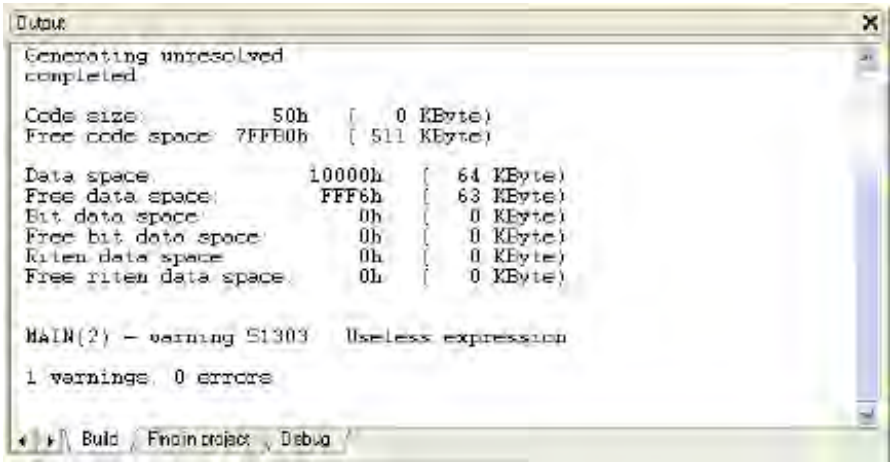
`m warnings, n errors`

It tells the user the outcome of compilation.

Condition	Description
n>0	Compiler error(s). The PLC code contains one or more serious errors, which cannot be worked around by the compiler.
n=0, m>0	Emission of warning(s). The PLC code contains one or more minor errors, which the compiler automatically spotted and worked around. However, you are informed that the PLC program may act in a different way from what you expected: you are encouraged to get rid of these warnings by editing and re-compiling the application until no warning messages are emitted.
n=m=0	PLC code entirely correct, compilation accomplished. You should always work with 0 warnings, 0 errors.

7.2.1 COMPILER ERRORS

When your application contains one or more errors, some useful information is printed in the *Output* window for each of those errors.

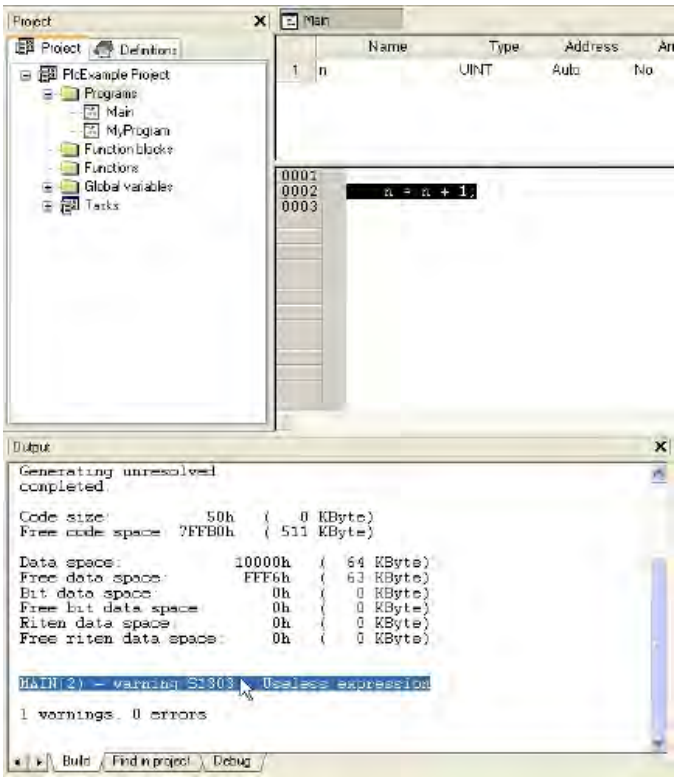

Output
Generating unresolved
completed
Code size: 50h (0 KByte)
Free code space: 7FFB0h (511 KByte)
Data space: 10000h (64 KByte)
Free data space: FFF6h (63 KByte)
Bit data space: 0h (0 KByte)
Free bit data space: 0h (0 KByte)
Xiten data space: 0h (0 KByte)
Free xiten data space: 0h (0 KByte)
MAIN(2) - warning S1303 Useless expression
1 warnings, 0 errors
Build
Find in project
Debug

As you can see, the information includes:

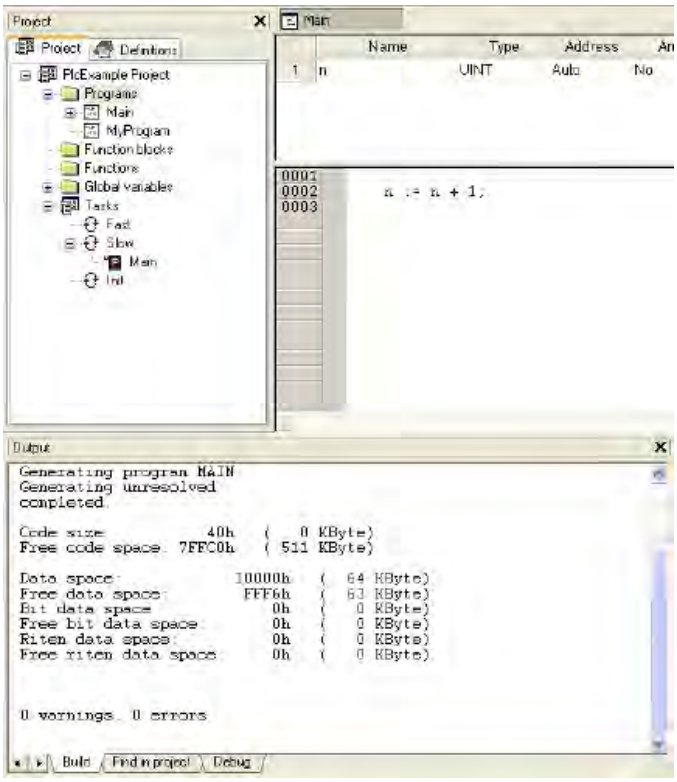
- the name of the Program Organization Unit affected by the error;
- the number of the source code line which procured the error;
- whether it is a fatal error (`error`) or one that the compiler could work around (`warning`);
- the error code;
- the error description.

Refer to the appropriate section for the compiler error reference.

If you double-click the error message in the *Output* bar, LogicLab opens the source code and highlights the line containing the error.



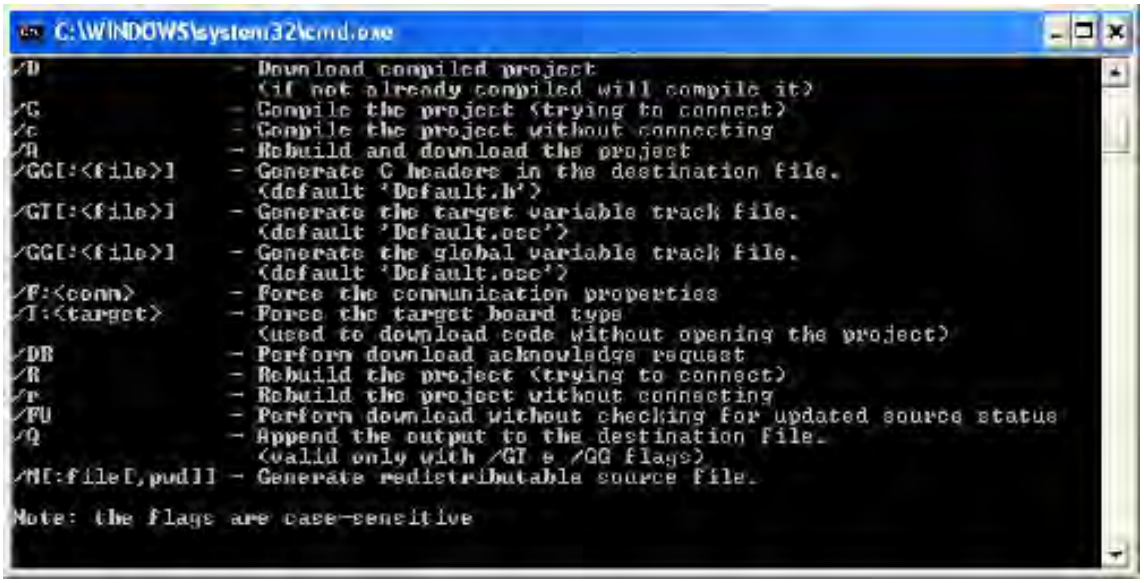
You can then solve the problem and re-compile.



7.3 COMMAND-LINE COMPILER

LogicLab's compiler can be used independently from the IDE: in LogicLab's directory, you can find an executable file, *Command-line compiler*, which can be invoked (for example, in a batch file) with a number of options.

In order to get information about the syntax and the options of this command-line tool, just launch the executable without parameters.


C:\WINDOWS\system32\cmd.exe
/D - Download compiled project
(if not already compiled will compile it)
/C - Compile the project (trying to connect)
/c - Compile the project without connecting
/A - Rebuild and download the project
/GC[:<file>] - Generate C headers in the destination file.
(default 'Default.h')
/GT[:<file>] - Generate the target variable track file.
(default 'Default.osc')
/GG[:<file>] - Generate the global variable track file.
(default 'Default.osc')
/F:<conn> - Force the communication properties
/T:<target> - Force the target board type
(used to download code without opening the project)
/DR - Perform download acknowledge request
/R - Rebuild the project (trying to connect)
/r - Rebuild the project without connecting
/FU - Perform download without checking for updated source status
/Q - Append the output to the destination file.
(valid only with /GT e /GG flags)
/MC:file[,pud]] - Generate redistributable source file.
Note: the flags are case-sensitive

8. LAUNCHING THE APPLICATION

In order to download and debug the application, you have to establish a connection with the target device. This chapter focuses on the operations required to connect to the target and to download the application, while the wide range of LogicLab's debugging tools deserves a separate chapter (see Chapter 9.).

8.1 SETTING UP THE COMMUNICATION

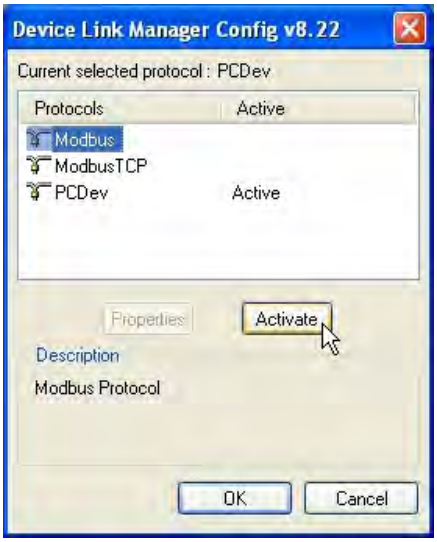
In order to establish the connection with the target device, make sure the physical link is up (all the cables are plugged in, the network is properly configured, and so on).

Follow this procedure to set up and establish the connection to the target device:

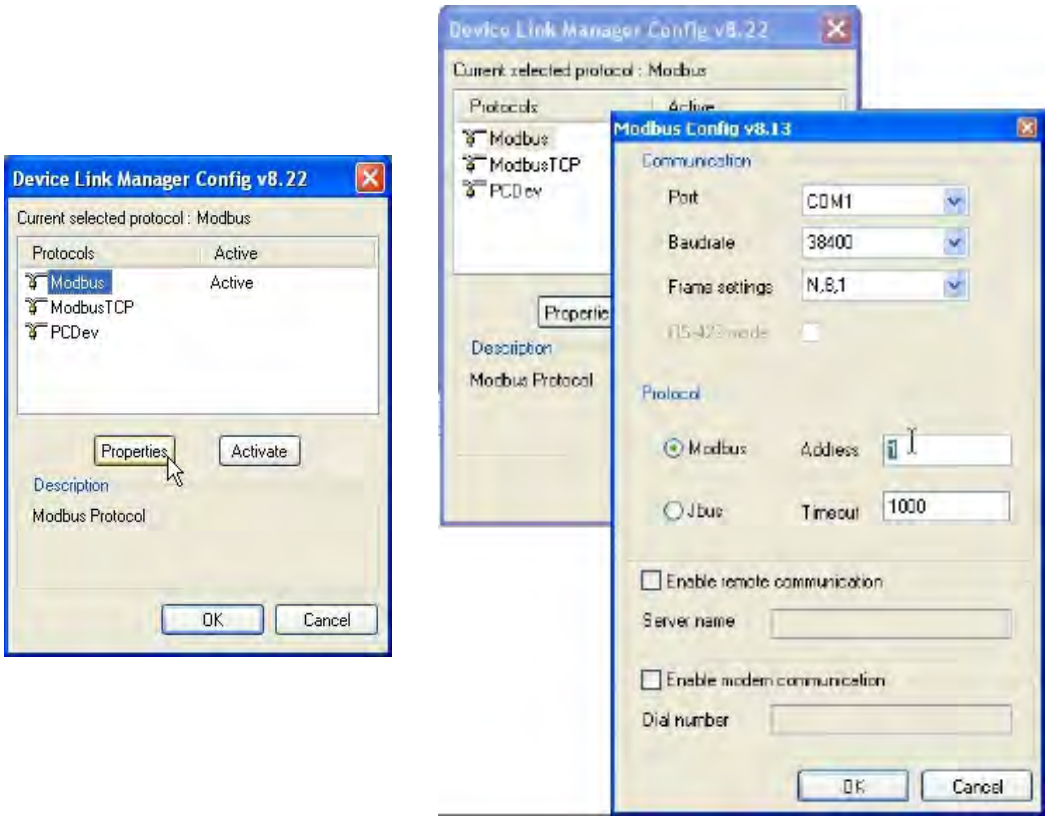
1) Click *Settings* in the *Communication* menu of the LogicLab main window. This causes the following dialog box to appear.

The elements in the list of communication protocols you can select from depend on the setup executable(s) you have run on your PC (refer to your hardware provider if a protocol you expect to appear in the list is missing).

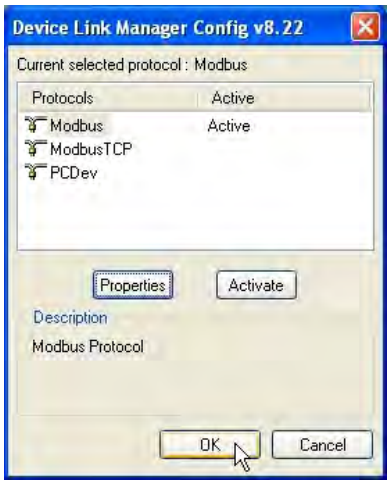
2) Choose the appropriate protocol and make it the active protocol.



3) Fill in all the protocol-specific settings (e.g., the address or the communication timeout - that is how long LogicLab must wait for an answer from the target before displaying a communication error message).



4) Apply the changes you made to the communication settings.



Now you can establish communication by clicking *Connect* in the *Communication* menu, or by pressing the *Connect* button in the *Project* toolbar.

8.1.1 SAVING THE LAST USED COMMUNICATION PORT

When you connect to target devices using a serial port (COM port), you usually use the same port for all devices (many modern PCs have only one COM port). You may save the last used COM port and let LogicLab use that port to override the project settings: this feature proves especially useful when you share projects with other developers, which may use a different COM port to connect to the target device.

In order to save your COM port settings, enable the *Use last port* option in *File > Options...* menu.

8.2 ON-LINE STATUS

8.2.1 CONNECTION STATUS

The state of communication is shown in a small box next to the right border of the *Status* bar.

If you have not yet attempted to connect to the target, the state of communication is set to *Not connected*.

When you try to connect to the target device, the state of communication becomes one of the following:

- Error: the communication cannot be established. You should check both the physical link and the communication settings.

- Connected: the communication has been established.

8.2.2 APPLICATION STATUS

Next to the communication status there is another small box which gives information about the status of the application currently executing on the target device.

When the connection status is Connected, the application status takes on one of the following values.

- No code: no application is executing on the target device.

- `Diff. code`: the application currently executing on the target device is not the same as the one currently open in the IDE; moreover, no debug information consistent with the running application is available: thus, the values shown in the watch window or in the oscilloscope are not reliable and the debug mode cannot be activated.

DIFF. CODE

- `Diff. code, Symbols OK`: the application currently executing on the target device is not the same as the one currently open in the IDE; however, some debug information consistent with the running application is available (for example, because that application has been previously downloaded to the target device from the same PC): the values shown in the watch window or in the oscilloscope are reliable, but the debug mode still cannot be activated.

DIFF. CODE (SYM)

- `Source OK`: the application currently executing on the target device is the same as the one currently open in the IDE: the debug mode can be activated.

SOURCE OK

8.3 DOWNLOADING THE APPLICATION

A compiled PLC application must be downloaded to the target device in order to have the processor execute it. This paragraph shows you how to send a PLC code to a target device. Note that LogicLab can download the code to the target device only if the latter is connected to the PC where LogicLab is running. See the related section for details.

To download the application, click on the related button in the *Project* toolbar.

Alternatively, you can choose *Download code* from the *Project* menu or press the *F5* key.

LogicLab checks whether the project has unsaved changes. If this is the case, it automatically starts the compilation of the application. The binary code is eventually sent to the target device, which then undergoes automatic reset at the end of transmission. Now the code you sent is actually executed by the processor on the target device.

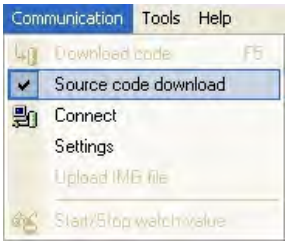
8.3.1 CONTROLLING SOURCE CODE DOWNLOAD

Whether the source code of the application is downloaded along with the binary code or not, depends on the target device you are interfacing with: some devices host the application source code in their storage, in order to allow the developer to upload the project in a later moment.

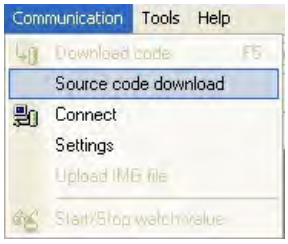
If this is the case, you can control some aspects of the source code download process, as explained in the following paragraphs.

8.3.1.1 SUSPENDING SOURCE CODE DOWNLOAD

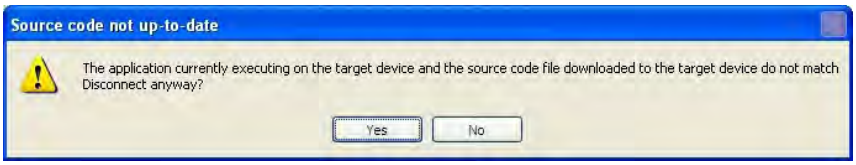
In order to speed up the development cycle, you may want to disable source code download: uncheck the *Source code download* item in the *Communication* menu.



When you stop developing the application, you can enable source code download again by checking the same menu item.



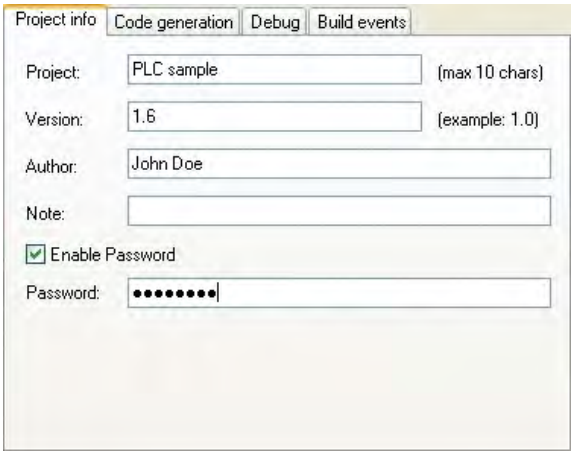
When you disconnect from the target device, LogicLab checks if the application currently executing on the target and the source code available on-board match, alerting you if they do not.


Source code not up-to-date
The application currently executing on the target device and the source code file downloaded to the target device do not match
Disconnect anyway?
Yes
No

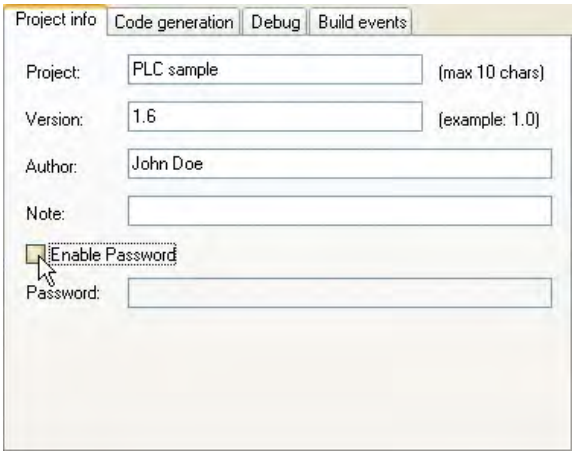
8.3.1.2 PROTECTING THE SOURCE CODE WITH A PASSWORD

You may want to protect the source code downloaded to the target device with a password, so that LogicLab will not open the uploaded project unless the correct password is entered.

Open the *Project options* window (*Project > Options ...* menu) and set the password.



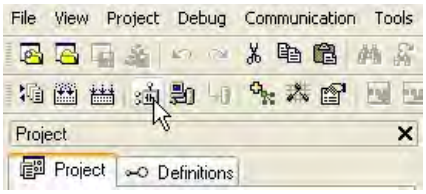
You may opt to disable the password, instead.



8.4 SIMULATION

Depending on the target device you are interfacing with, you may be able to simulate the execution of the PLC application with LogicLab's integrated simulation environment: SimuLab.

In order to start the simulation, just click on the appropriate item on the *Project* toolbar.



Refer to SimuLab's manual to gain information on how to control the simulation.

9. DEBUGGING

LogicLab provides several debugging tools, which help the developer to check whether the application behaves as expected or not.

All these debugging tools basically allow the developer to watch the value of selected variables while the PLC application is running.

LogicLab debugging tools can be gathered in two classes:

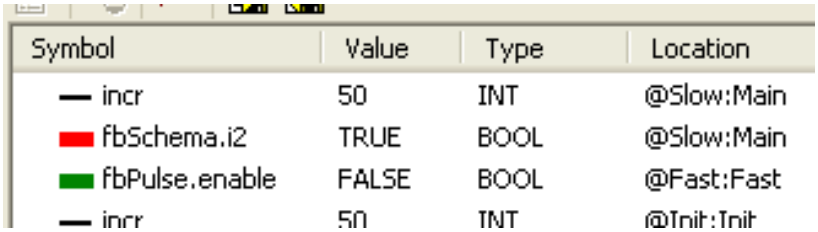
- Asynchronous debuggers. They read the values of the variables selected by the developer with successive queries issued to the target device. Both the manager of the debugging tool (that runs on the PC) and, potentially, the task which is responsible to answer those queries (on the target device) run independently from the PLC application. Thus, there is no guarantee about the values of two distinct variables being sampled in the same moment, with respect to the PLC application execution (one or more cycles may have occurred); for the same reason, the evolution of the value of a single variable is not reliable, especially when it changes fast.
- Synchronous debuggers. They require the definition of a trigger in the PLC code. They refresh simultaneously all the variables they have been assigned every time the processor reaches the trigger, as no further instruction can be executed until the value of all the variables is refreshed. As a result, synchronous debuggers obviate the limitations affecting asynchronous ones.

This chapter shows you how to debug your application using both asynchronous and synchronous tools.

9.1 WATCH WINDOW

The *Watch* window allows you to monitor the current values of a set of variables. Being an asynchronous tool, the *Watch* window does not guarantee synchronization of values. Therefore, when reading the values of the variables in the *Watch* window, be aware of the possibility that they may refer to different execution cycles of the corresponding task.

The *Watch* window contains an item for each variable that you added to it. The information shown in the *Watch* window includes the name of the variable, its value, its type, and its location in the PLC application.



9.1.1 OPENING AND CLOSING THE WATCH WINDOW

To open the *Watch* window, click on the *Watch* button of the *Main* toolbar.

To close the *Watch* window, click on the *Watch* button again.

Alternatively, you can click on the *Close* button in the top right corner of the *Watch* window.

In both cases, closing the *Watch* window means simply hiding it, not resetting it. As a matter of fact, if you close the *Watch* window and then open it again, you will see that it still contains all the variables you added to it.

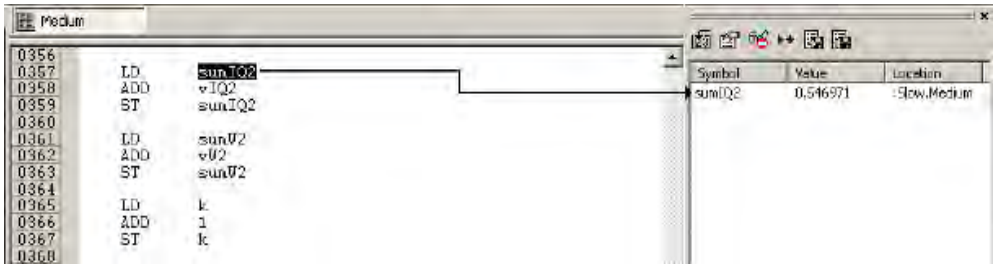
9.1.2 ADDING ITEMS TO THE WATCH WINDOW

To watch a variable, you need to add it to the watch list.

Note that, unlike trigger windows and the *Graphic trigger* window, you can add to the *Watch* window all the variables of the project, regardless of where they were declared.

9.1.2.1 ADDING A VARIABLE FROM A TEXTUAL SOURCE CODE EDITOR

Follow this procedure to add a variable to the *Watch* window from a textual (that is, IL or ST) source code editor: select a variable, by double-clicking on it, and then drag it into the watch window.



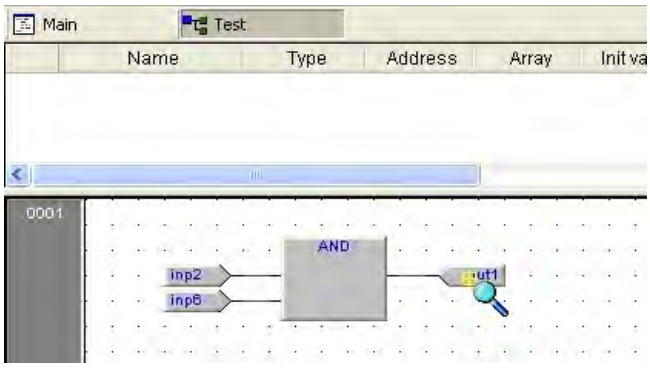
The same procedure applies to all the variables you wish to inspect.

9.1.2.2 ADDING A VARIABLE FROM A GRAPHICAL SOURCE CODE EDITOR

Follow this procedure to add a variable to the *Watch* window from a graphical (that is, LD, FBD, or SFC) source code editor:

1) Press the *Watch* button in the FBD bar.

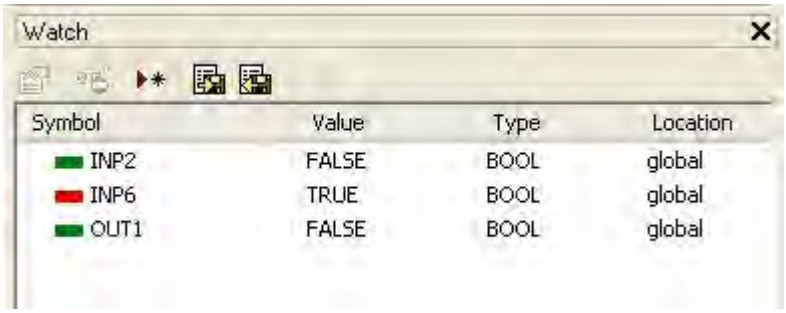
2) Click on the block representing the variable you wish to be shown in the *Watch* window.



3) A dialog box appears listing all the currently existing instances of debug windows, and asking you which one is to receive the object you have just clicked on.

In order to display the variable in the *Watch* window, select *Watch*, then press *OK*.

The variable name, value, and location are now displayed in a new row of the *Watch* window.

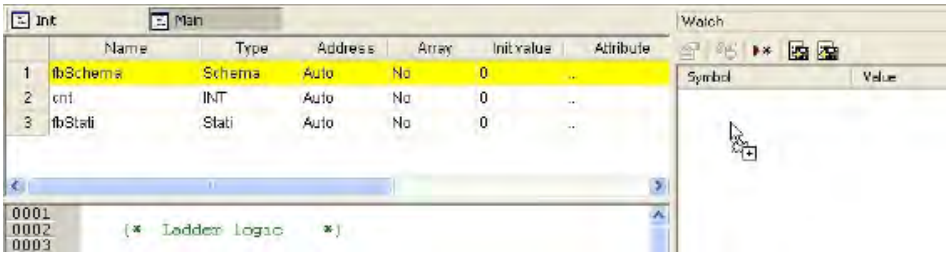


The same procedure applies to all the variables you wish to inspect.

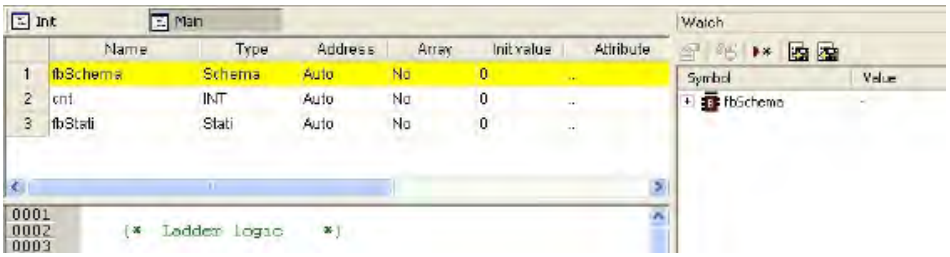
Once you have added to the *Watch* window all the variables you want to observe, you should click on the *Select/Move* button in the FBD bar: the mouse cursor turns to its original shape.

9.1.2.3 ADDING A VARIABLE FROM A VARIABLES EDITOR

In order to add a variable to the *Watch* window, you can select the corresponding record in the variables editor and then either drag-and-drop it in the *Watch* window

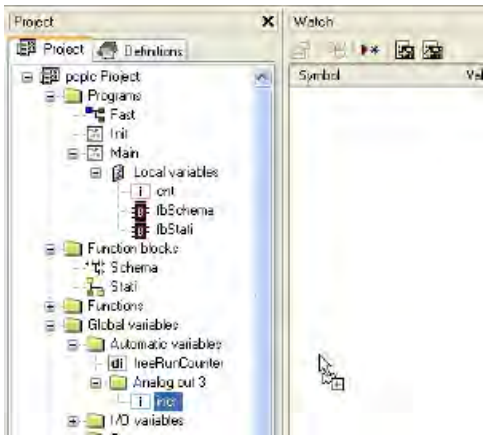


or press the *F8* key.

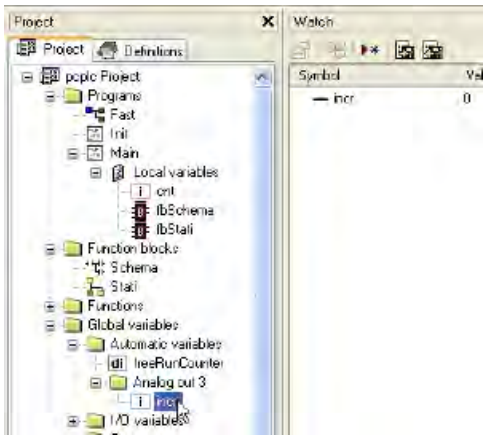


9.1.2.4 ADDING A VARIABLE FROM THE PROJECT TREE

In order to add a variable to the *Watch* window, you can select it in the project tree and then either drag-and-drop it in the *Watch* window

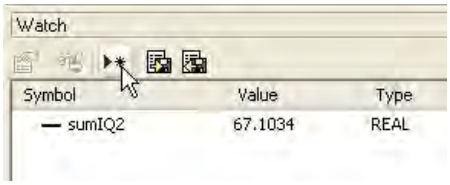


or press the *F8* key.



9.1.2.5 ADDING A VARIABLE FROM THE WATCH WINDOW TOOLBAR

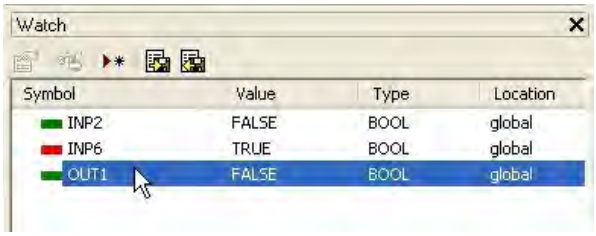
You can also click on the appropriate item of the Watch window inner toolbar, in order to add a variable to it.

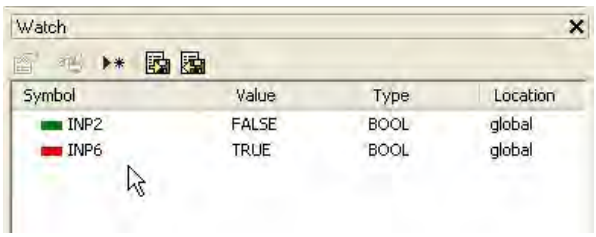


You shall type (or select by browsing the project symbols) the name of the variable and its location (where it has been declared).

9.1.3 REMOVING A VARIABLE

If you want a variable not to be displayed any more in the *Watch* window, select it by clicking on its name once, then press the *Del* key.

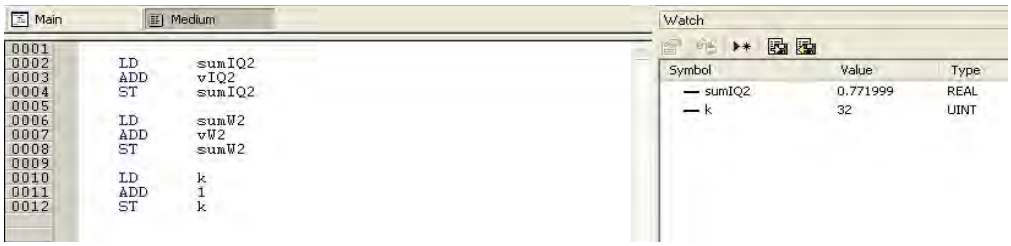




9.1.4 REFRESHMENT OF VALUES

9.1.4.1 NORMAL OPERATION

Let us consider the following example.

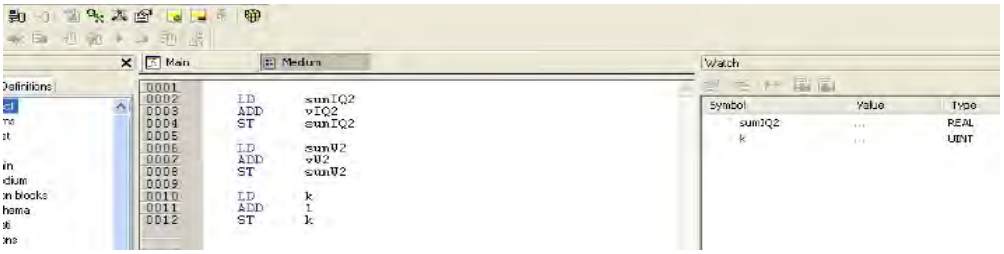


The watch window manager reads periodically from memory the value of the variables.

However, this action is carried out asynchronously , that is it may happen that a higher-priority task modifies the value of some of the variables while they are being read. Thus, at the end of a refreshment process, the values displayed in the window may refer to different execution states of the PLC code.

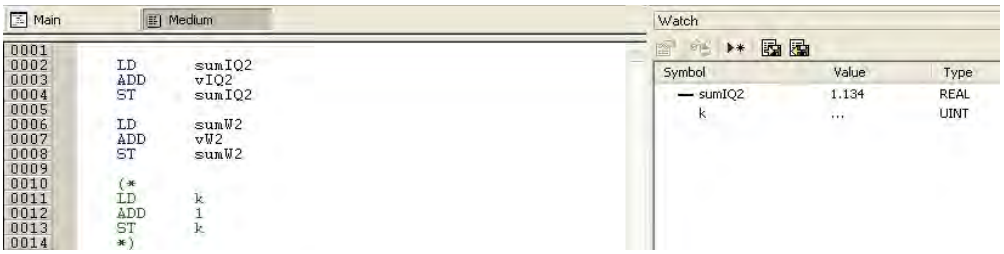
9.1.4.2 TARGET DISCONNECTED

If the target device is disconnected, the *Value* column contains three dots.

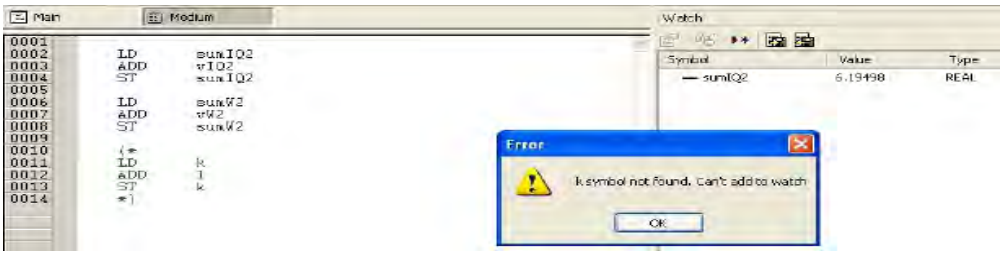


9.1.4.3 OBJECT NOT FOUND

If the PLC code changes and LogicLab cannot retrieve the memory location of an object in the *Watch* window, then the *Value* column contains three dots.



If you try to add to the *Watch* window a symbol which has not been allocated, LogicLab gives the following error message.

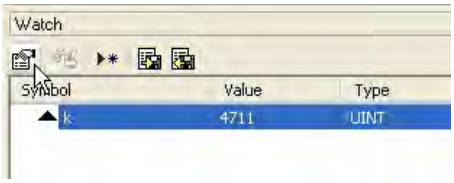


9.1.5 CHANGING THE FORMAT OF DATA

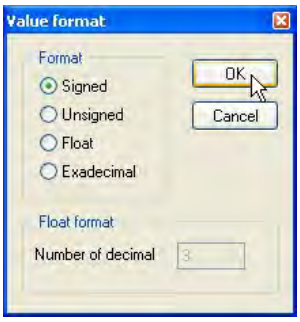
When you add a variable to the *Watch* window, LogicLab automatically recognizes its type (unsigned integer, signed integer, floating point, hexadecimal), and displays its value consistently. Also, if the variable is floating point, LogicLab assigns it a default number of decimal figures.

However, you may need the variable to be printed in a different format.

To impose another format than the one assigned by LogicLab, press the *Format value* button in the toolbar.



Choose the format and confirm your choice.

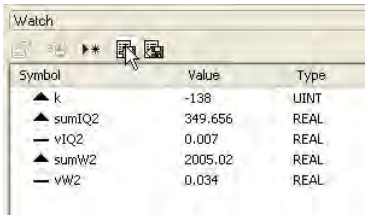


9.1.6 WORKING WITH WATCH LISTS

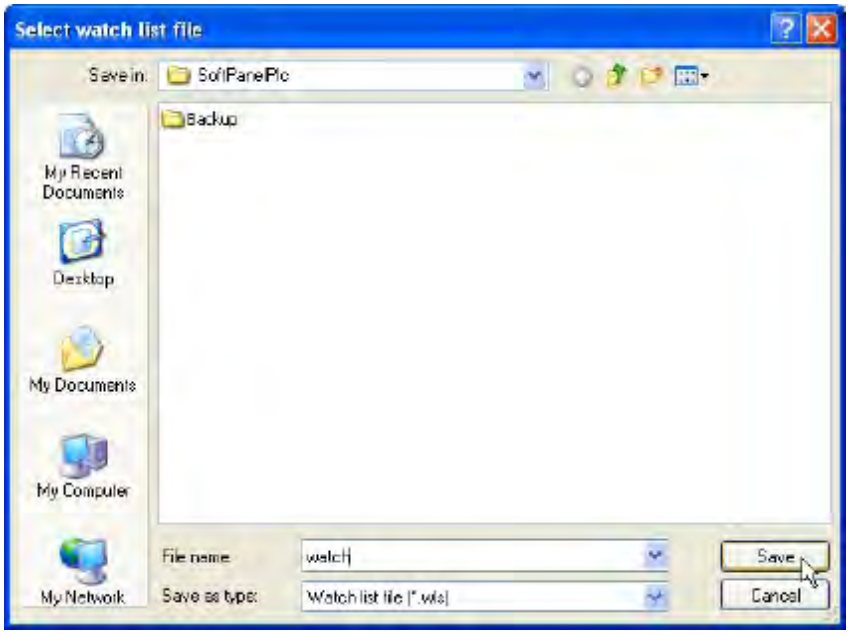
You can store to file the set of all the items in the *Watch* window, in order to easily restore the status of this debugging tools in a successive working session.

Follow this procedure to save a watch list:

1) Click on the corresponding item in the *Watch window* toolbar.

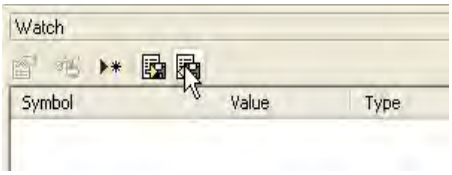


2) Enter the file name and choose its destination in the file system.

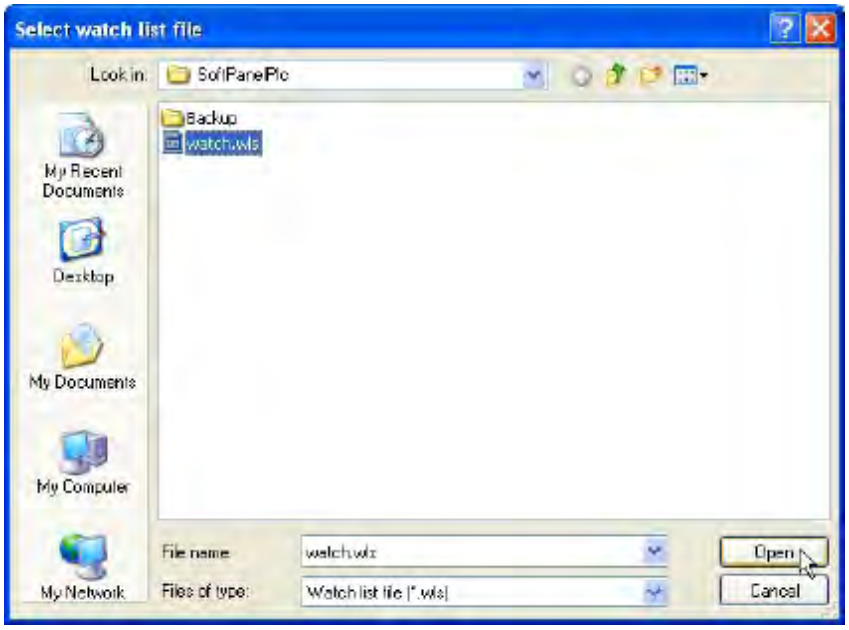


In order to load a watch list, follow this procedure:

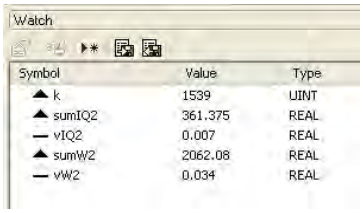
1) Click on the corresponding item in the *Watch window* toolbar.



2) Browse the file system and select the watch list file.



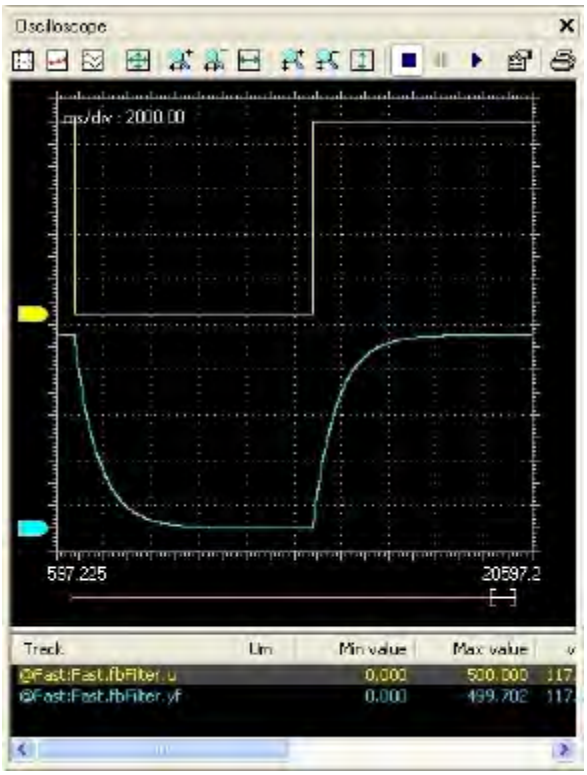
The set of symbols in the watch list is added to the *Watch* window.



9.2 OSCILLOSCOPE

The Oscilloscope allows you to plot the evolution of the values of a set of variables. Being an asynchronous tool, the Oscilloscope cannot guarantee synchronization of samples.

Opening the Oscilloscope causes a new window to appear next to the right-hand border of the LogicLab frame. This is the interface for accessing the debugging functions that the Oscilloscope makes available. The Oscilloscope consists of three elements, as shown in the following picture.



The toolbar allows you to better control the Oscilloscope. A detailed description of the function of each control is given later in this chapter.

The Chart area includes several items:

- Plot: area containing the curve of the variables.
- Vertical cursors: cursors identifying two distinct vertical lines. The values of each variable at the intersection with these lines are reported in the corresponding columns.
- Scroll bar: if the scale of the x-axis is too large to display all the samples in the Plot area, the scroll bar allows you to slide back and forth along the horizontal axis.

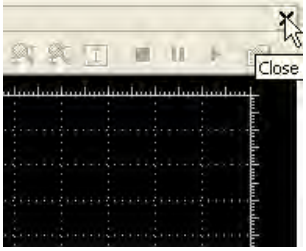
The lower section of the Oscilloscope is a table consisting of a row for each variable.

9.2.1 OPENING AND CLOSING THE OSCILLOSCOPE

To open the Oscilloscope, click on the *Async* button of the *Main* toolbar.

To close the Oscilloscope, click on the *Async* button again.

Alternatively, you can click on the *Close* button in the top right corner of the *Oscilloscope* window.



In both cases, closing the Oscilloscope means simply hiding it, not resetting it. As a matter of fact, if you open again the Oscilloscope after closing it, you will see that plotting of the curve of all the variables you added to it starts again.

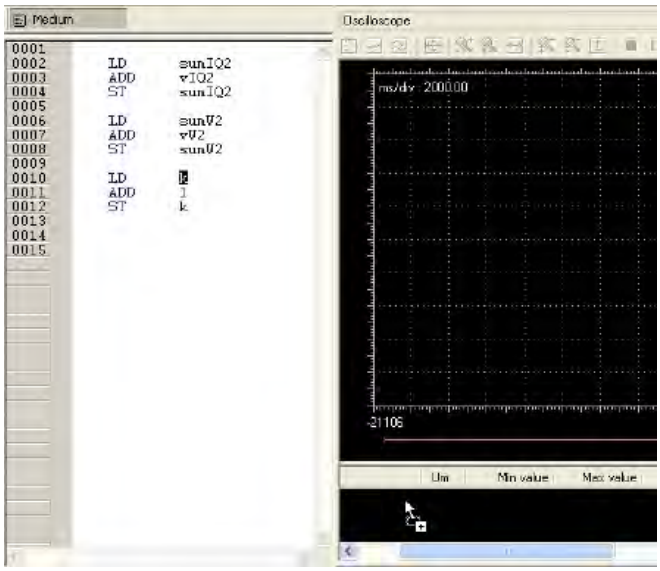
9.2.2 ADDING ITEMS TO THE OSCILLOSCOPE

In order to plot the evolution of the value of a variable, you need to add it to the Oscilloscope.

Note that unlike trigger windows and the *Graphic trigger* window, you can add to the Oscilloscope all the variables of the project, regardless of where they were declared.

9.2.2.1 ADDING A VARIABLE FROM A TEXTUAL SOURCE CODE EDITOR

Follow this procedure to add a variable to the Oscilloscope from a textual (that is, IL or ST) source code editor: select a variable by double-clicking on it, and then drag it into the *Oscilloscope* window.



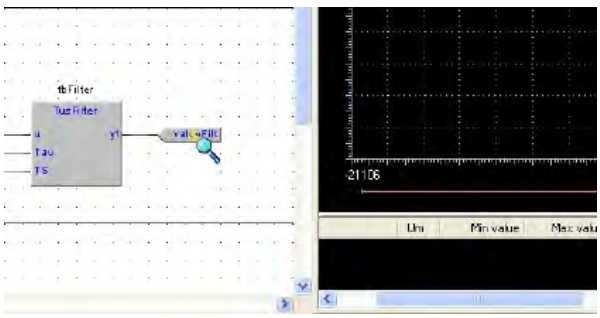
The same procedure applies to all the variables you wish to inspect.

9.2.2.2 ADDING A VARIABLE FROM A GRAPHICAL SOURCE CODE EDITOR

Follow this procedure to add a variable to the Oscilloscope from a graphical (that is, LD, FBD, or SFC) source code editor:

1) Press the *Watch* button in the *FBD* bar.

2) Click on the block representing the variable you wish to be shown in the Oscilloscope.



3) A dialog box appears listing all the currently existing instances of debug windows, and asking you which one is to receive the object you have just clicked on.

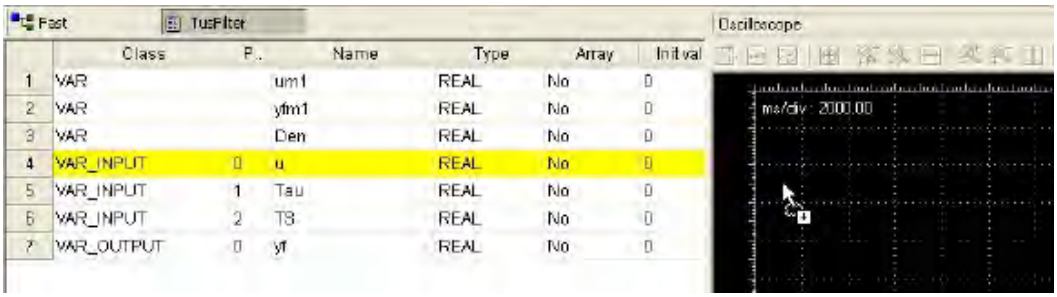
Select *Oscilloscope*, the press *OK*. The name of the variable is now displayed in the *Track* column.

The same procedure applies to all the variables you wish to inspect.

Once you have added to the Oscilloscope all the variables you want to observe, you should click on the *Select/Move* button in the *FBD* bar: the mouse cursor turns to its original shape.

9.2.2.3 ADDING A VARIABLE FROM A VARIABLES EDITOR

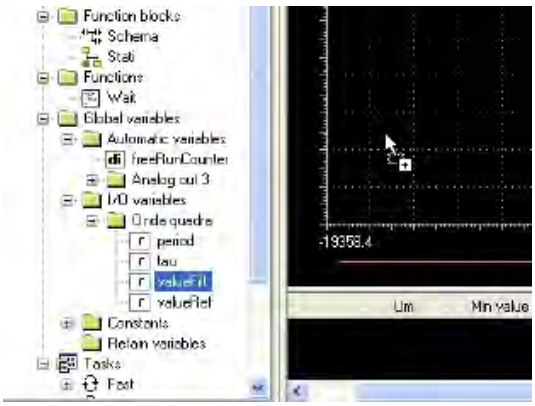
In order to add a variable to the Oscilloscope, you can select the corresponding record in the variables editor and then either drag-and-drop it in the Oscilloscope



or press the *F10* key and choose *Oscilloscope* from the list of debug windows which pops up.

9.2.2.4 ADDING A VARIABLE FROM THE PROJECT TREE

In order to add a variable to the Oscilloscope, you can select it in the project tree and then either drag-and-drop it in the Oscilloscope



or press the *F10* key and choose *Oscilloscope* from the list of debug windows which pops up.

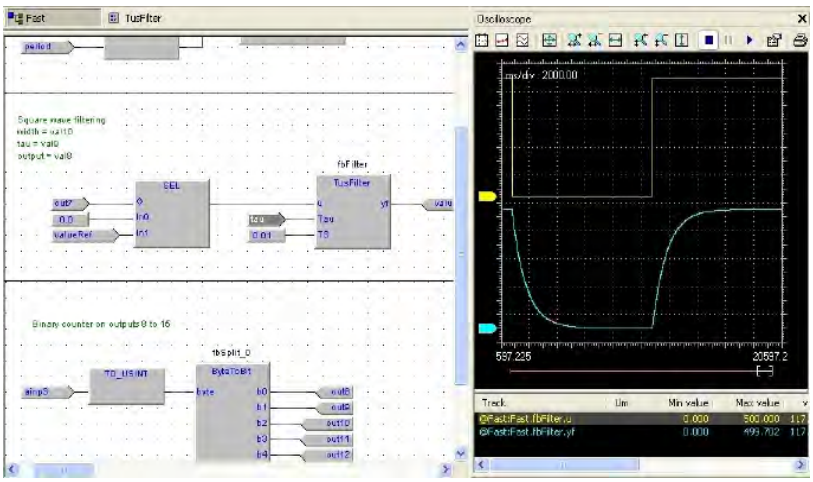
9.2.3 REMOVING A VARIABLE

If you want to remove a variable from the Oscilloscope, select it by clicking on its name once, then press the *Del* key.

9.2.4 VARIABLES SAMPLING

9.2.4.1 NORMAL OPERATION

Let us consider the following example.



The Oscilloscope manager periodically reads from memory the value of the variables.

However, this action is carried out asynchronously, that is it may happen that a higher-priority task modifies the value of some of the variables while they are being read. Thus, at the end of a sampling process, data associated with the same value of the x-axis may actually refer to different execution states of the PLC code.

9.2.4.2 TARGET DISCONNECTED

If the target device is disconnected, the curves of the dragged-in variables get frozen, until communication is restored.

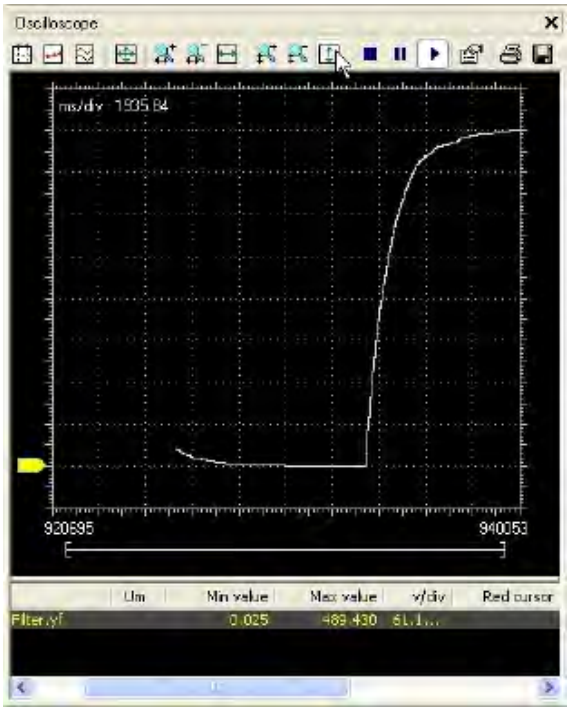
9.2.5 CONTROLLING DATA ACQUISITION AND DISPLAY

The Oscilloscope includes a toolbar with several commands, which can be used to control the acquisition process and the way data are displayed. This paragraph focuses on these commands.

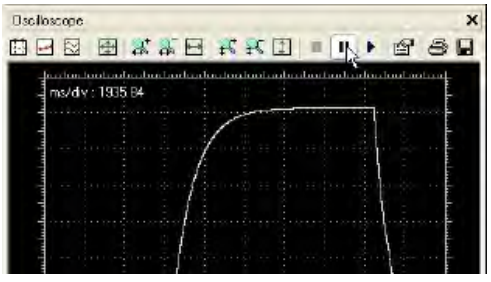
Note that all the commands in the toolbar are disabled if no variable has been added to the Oscilloscope.

9.2.5.1 STARTING AND STOPPING DATA ACQUISITION

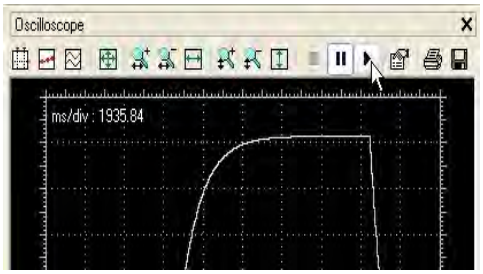
When you add a variable to the Oscilloscope, data acquisition begins immediately.



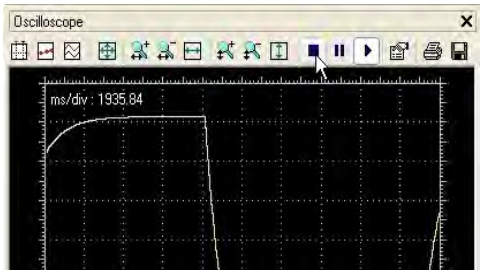
However, you can suspend the acquisition by clicking on *Pause acquisition*.



The curve freezes (while the process of data acquisition is still running in background), until you click on *Restart acquisition*.



In order to stop the acquisition you may click on *Stop acquisition*.

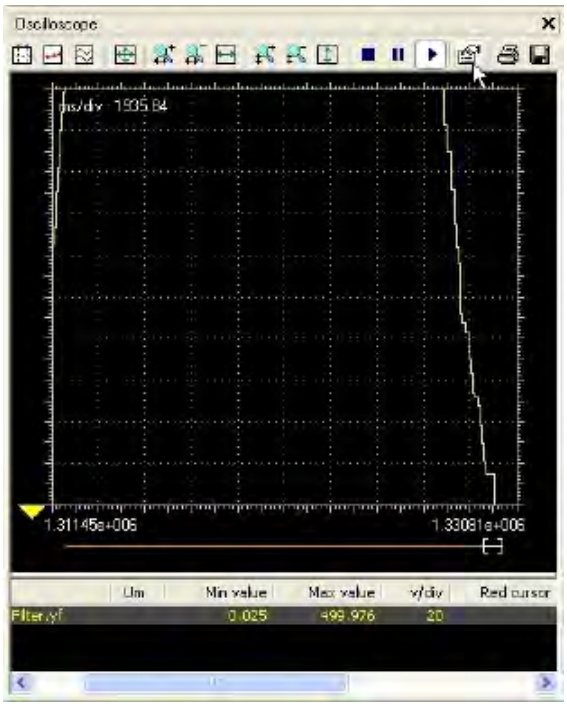


In this case, when you click on *Restart acquisition*, the evolution of the value of the variable is plotted from scratch.

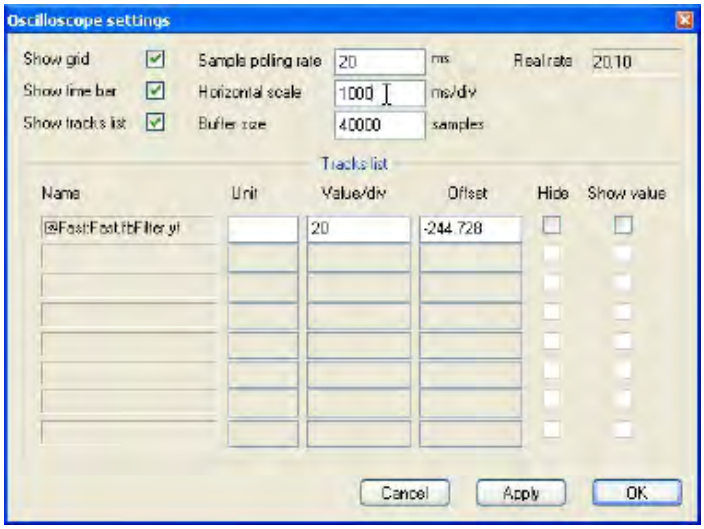
9.2.5.2 SETTING THE SCALE OF THE AXES

When you open the Oscilloscope, LogicLab applies a default scale to the axes. However, if you want to set a different scale, you may follow this procedure:

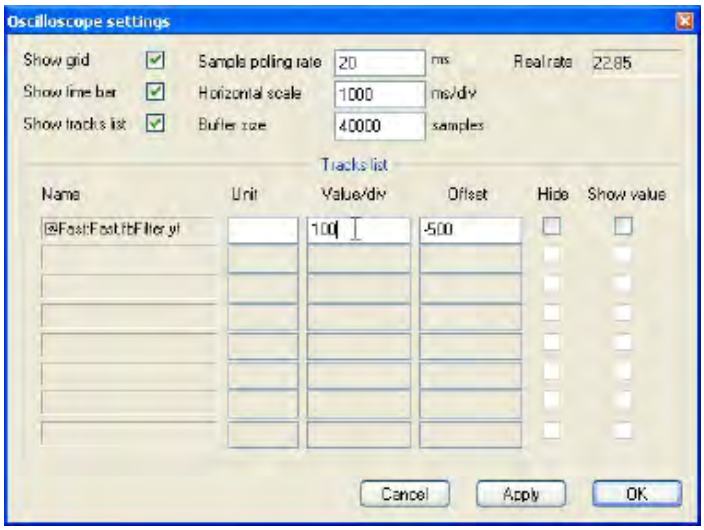
1) Open the graph properties by clicking on the corresponding item in the toolbar.



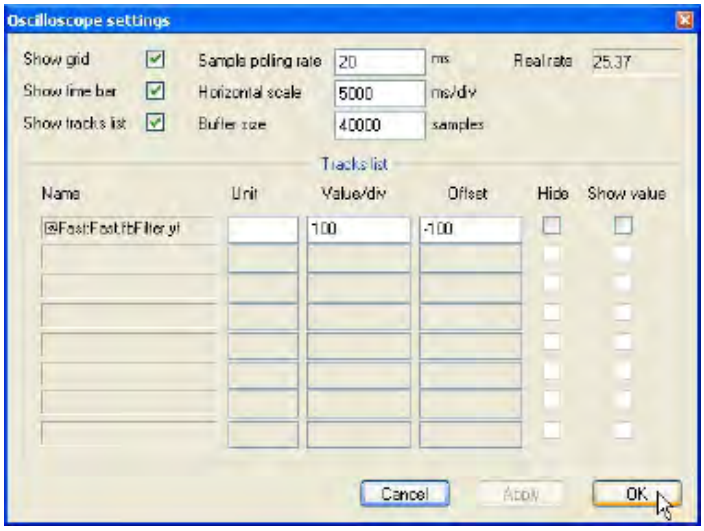
2) Set the scale of the horizontal axis, which is common to all the tracks.

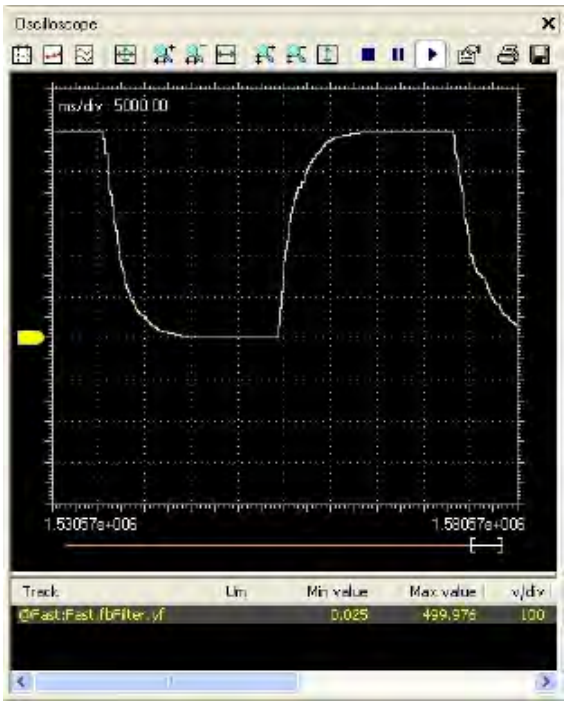


3) For each variable, you may specify a distinct scale for the vertical axis.

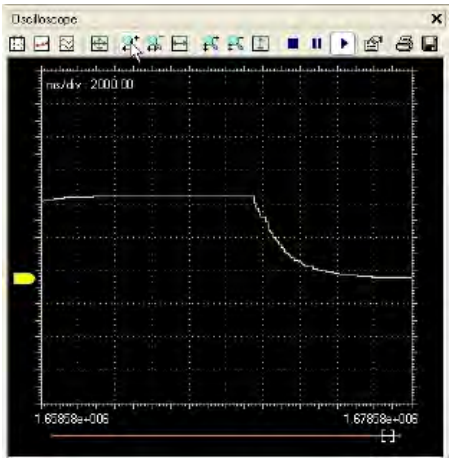


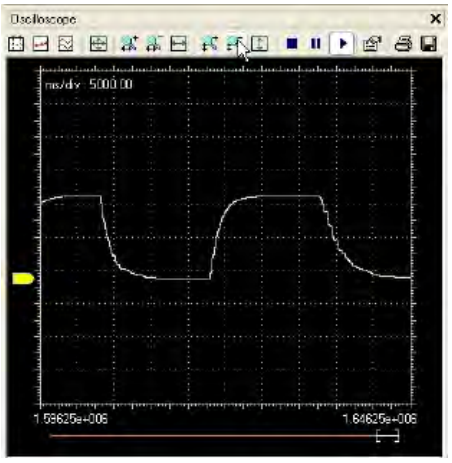
4) Confirm your settings. The graph adapts to reflect the new scale.



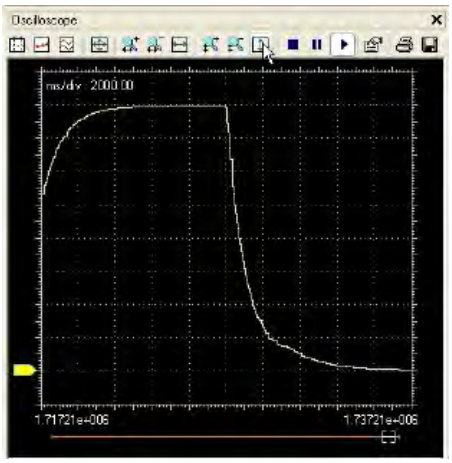


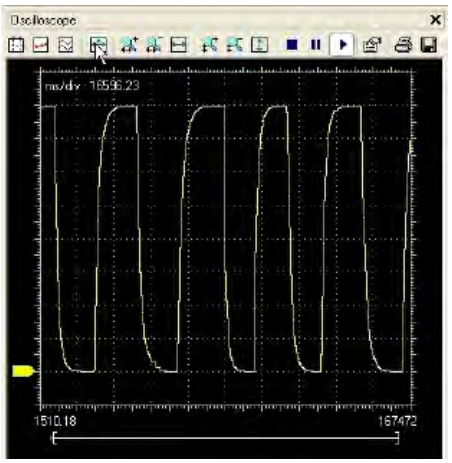
You can also zoom in and out with respect to both the horizontal and the vertical axes.





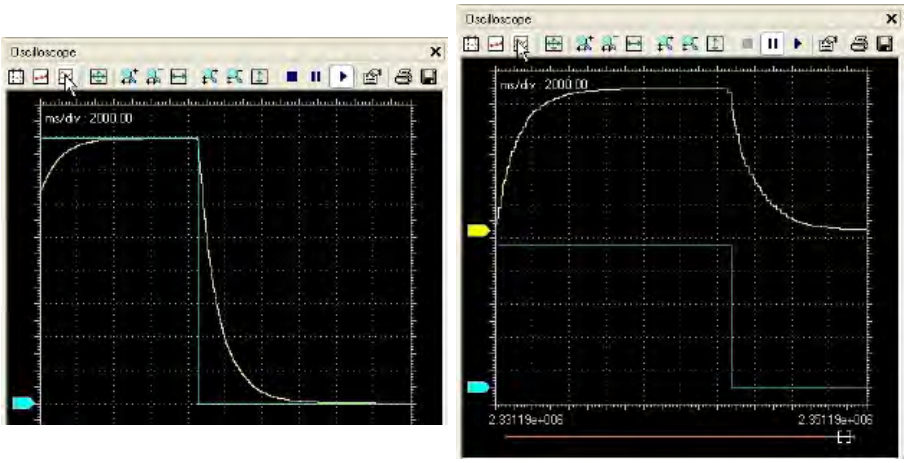
Finally, you may also quickly adapt the scale of the horizontal axis, the vertical axis, or both to include all the samples, by clicking on the corresponding item of the toolbar.





9.2.5.3 VERTICAL SPLIT

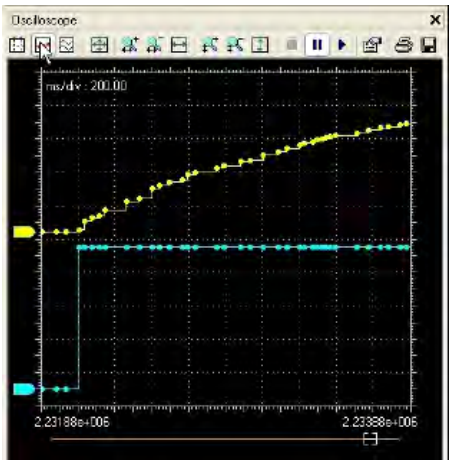
When you are watching the evolution of two or more variables, you may want to split the respective tracks. For this purpose, click on the *Vertical split* item in the *Oscilloscope* toolbar.



9.2.5.4 VIEWING SAMPLES

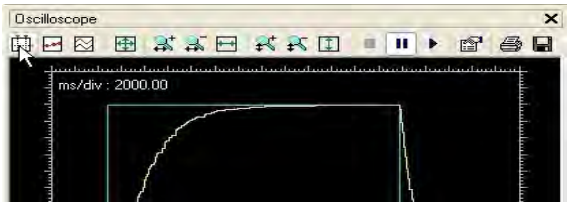
If you click on the *Show samples* item in the *Oscilloscope* toolbar, the tool highlights the single values detected during data acquisition.

You can click on the same item again, in order to go back to the default view mode.

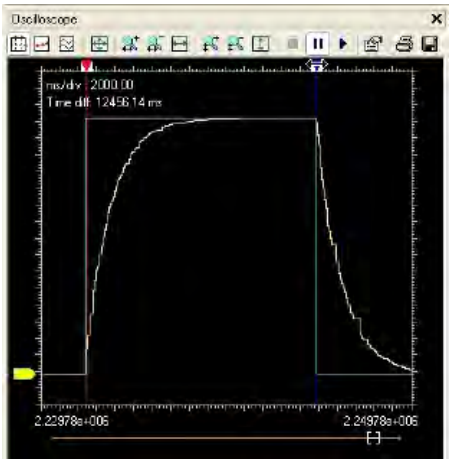


9.2.5.5 TAKING MEASURES

The Oscilloscope includes two measure bars, which can be exploited to take some measures on the chart; in order to show and hide them, click on the *Show measure bars* item in the *Oscilloscope* toolbar.

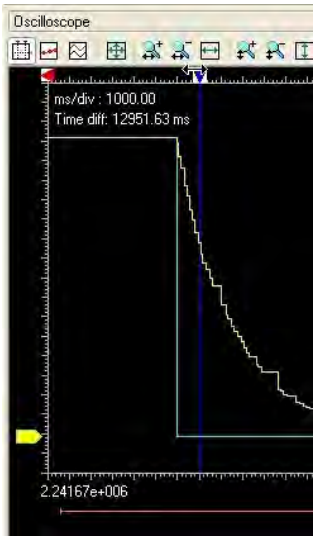


If you want to measure a time interval between two events, you just have to move one bar to the point in the graph that corresponds to the first event and the other to the point that corresponds to the second one.

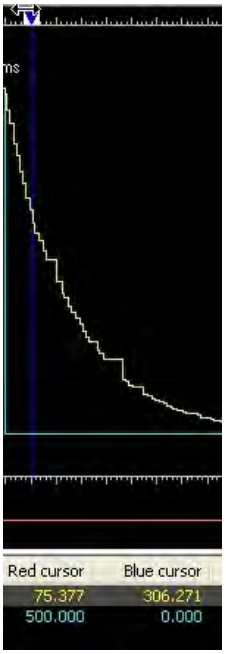


The time interval between the two bars is shown in the top left corner of the chart.

You can use a measure bar also to read the value of all the variables in the Oscilloscope at a particular moment: move the bar to the point in the graph which corresponds to the instant you want to observe.



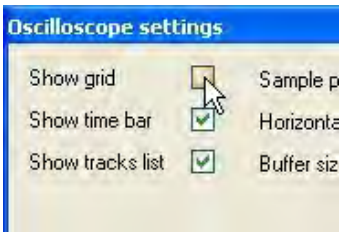
In the table below the chart, you can now read the values of all the variables at that particular moment.



9.2.5.6 OSCILLOSCOPE SETTINGS

You can further customize the appearance of the Oscilloscope by clicking on the *Graph properties* item in the toolbar.

In the window that pops up you can choose whether to display or not the *Background grid*, the *Time slide bar*, and the *Track list*.



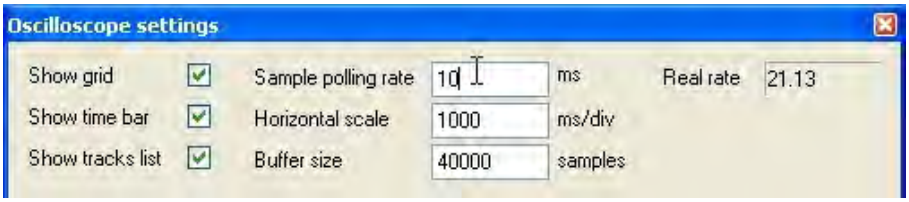
9.2.6 CHANGING THE POLLING RATE

LogicLab periodically sends queries to the target device, in order to read the data to be plotted in the Oscilloscope.

The polling rate can be configured by following this procedure:

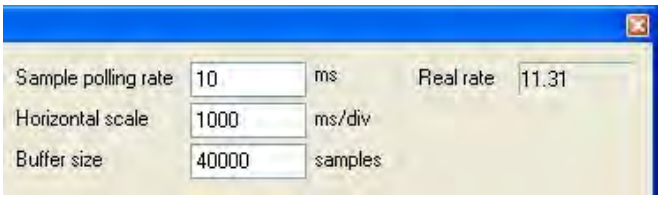
1) Click on the *Graph properties* item in the toolbar.

2) In the window that pops up edit the *Sampling polling rate*.



3) Confirm your decision.

Note that the actual rate depends on the performance of the target device (in particular, on the performance of its communication task). You can read the actual rate in the *Oscilloscope settings* window.



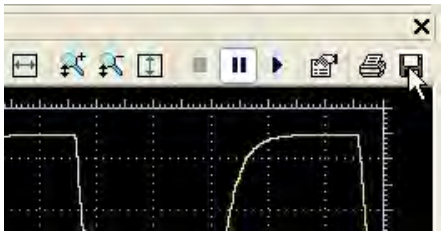
9.2.7 SAVING AND PRINTING THE GRAPH

LogicLab allows you to persist the acquisition either by saving the data to a file or by printing a view of the data plotted in the Oscilloscope.

9.2.7.1 SAVING DATA TO A FILE

You can save the samples acquired by the Oscilloscope to a file, in order to further analyze the data with other tools.

1) You may want to stop acquisition before saving data to a file.
2) Click on the *Save tracks data into file* in the *Oscilloscope* toolbar.



3) Choose between the available output file format: OSC is a simple plain-text file, containing time and value of each sample; OSCX is an XML file, that includes more complete information, which can be further analyzed with another tool, provided separately from LogicLab.

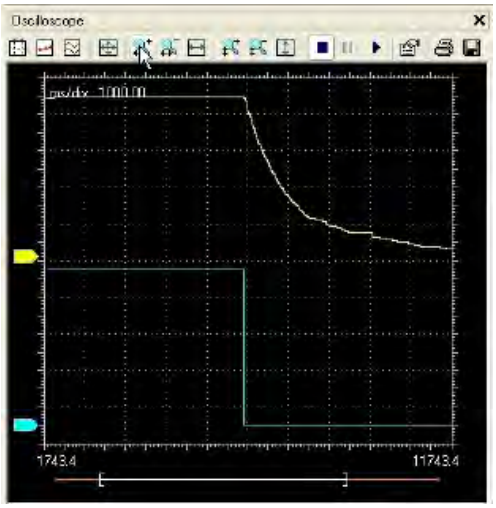
4) Choose a file name and a destination directory, then confirm the operation.

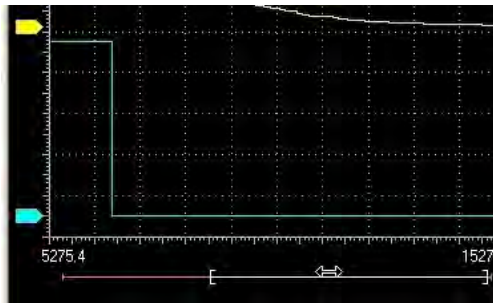
9.2.7.2 PRINTING THE GRAPH

Follow this procedure to print a view of the data plotted in the Oscilloscope:

1) Either suspend or stop the acquisition.

2) Move the time slide bar and adjust the zoom, in order to include in the view the elements you want to print.





3) Click on the *Print graph* item.

9.3 EDIT AND DEBUG MODE

While both the *Watch* window and the Oscilloscope do not make use of the source code, all the other debuggers do: thus, LogicLab requires the developer to switch on the debug mode, where changes to the source code are inhibited, before (s)he can access those debugging tools.

To switch on and off the debug mode, you can click on the corresponding item in the *Debug* toolbar.

Alternatively, you can choose *Debug mode* from the *Project* menu.

The status bar shows whether the debug mode is active or not.

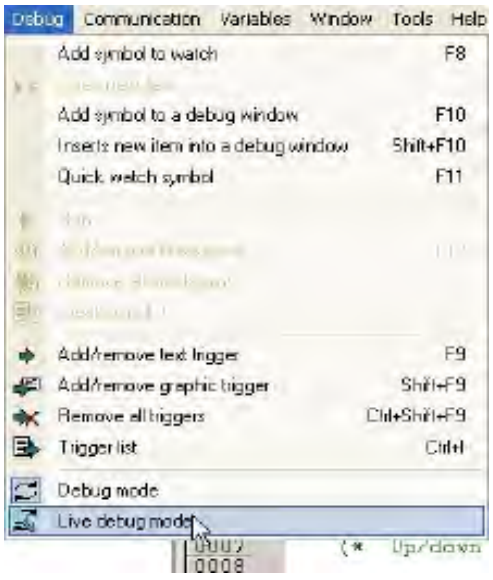
Note that you cannot enter the debug mode if the connection status differs from *Connected*.

9.4 LIVE DEBUG

LogicLab can display meaningful animation of the current and changing state of execution over time of a Program Organization Unit (POU) coded in any IEC 61131-3 programming language.

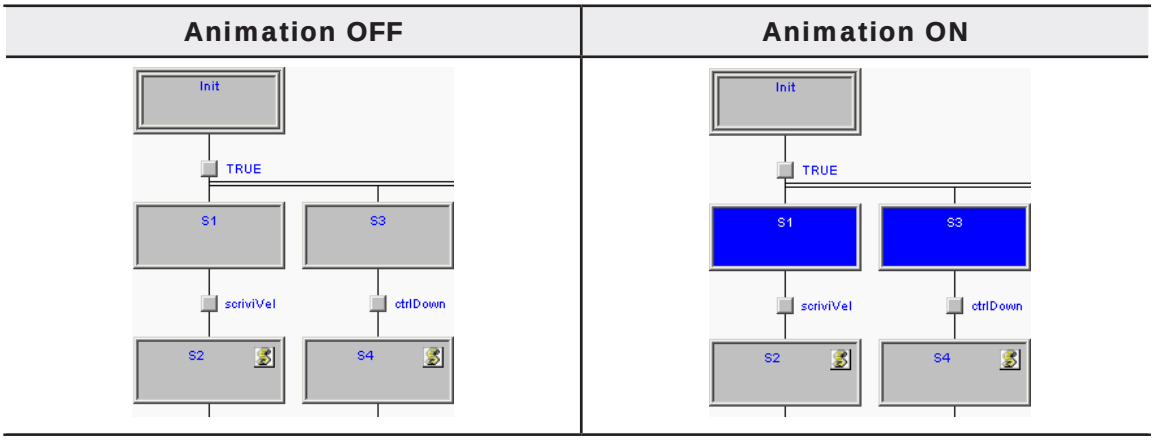
To switch on and off the live debug mode, you may click on the corresponding item in the *Debug* toolbar

or choose *Live debug mode* from the *Project* menu.



9.4.1 SFC ANIMATION

As explained in the relevant section of the language reference, an SFC POU is structured in a set of steps, each of which is either active or inactive at any given moment. Once started up, this SFC-specific debugging tool animates the SFC documents by highlighting the active steps.



In the left column, a portion of an SFC network is shown, diagram animation being off.

In the right column the same portion of network is displayed when the live debug mode is active. The picture in the right column shows that steps *S1* and *S3* are currently active, whereas *Init*, *S2*, and *S4* are inactive.

Note that the SFC animation manager tests periodically the state of all steps, the user not being allowed to edit the sampling period. Therefore, it may happen that a step remains active for a slot of time too short to be displayed on the video.

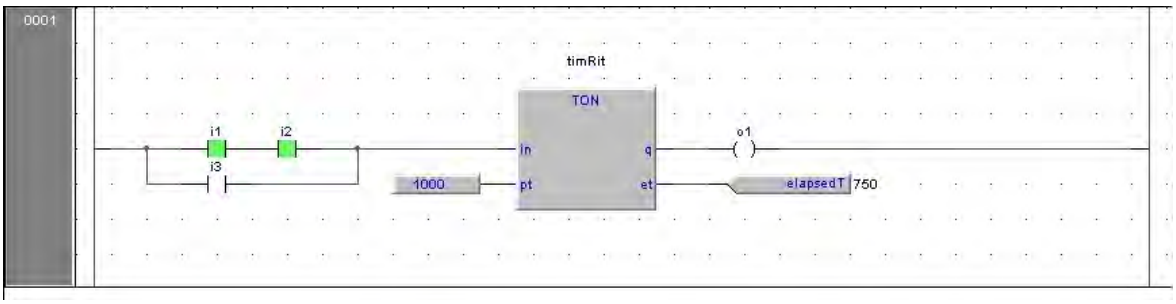
The fact that a step is never highlighted does not imply that its action is not executed, it may simply mean that the sampling rate is too slow to detect the execution.

9.4.1.1 DEBUGGING ACTIONS AND CONDITIONS

As explained in the SFC language reference, a step can be assigned to an action, and a transition can be associated with a condition code. Actions and conditions can be coded in any of the IEC 61131-3 languages. General-purpose debugging tools can be used within each action/condition, as if it was a stand-alone POU.

9.4.2 LD ANIMATION

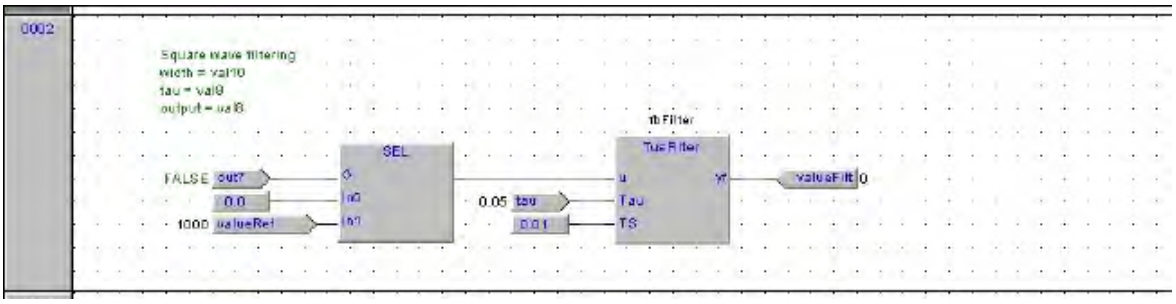
In live debug mode, Ladder Diagram schemes are animated by highlighting the contacts and coils whose value is true (in the example, i1 and i2).



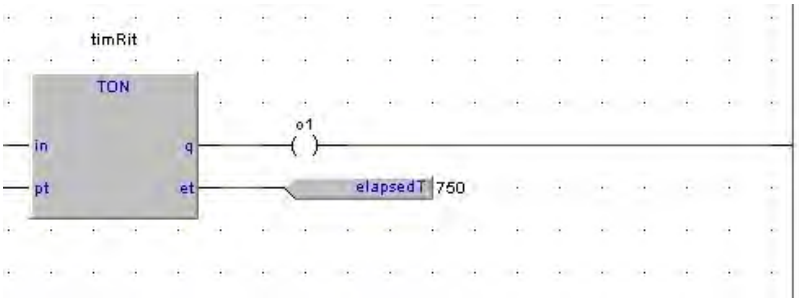
Note that the LD animation manager tests periodically the state of all the elements. It may happen that an element remains true for a slot of time too short to be displayed on the video. The fact that an element is never highlighted does not imply that its value never becomes true (the sampling rate may be too slow).

9.4.3 FBD ANIMATION

In live debug mode, LogicLab displays the values of all the visible variables directly in the graphical source code editor.



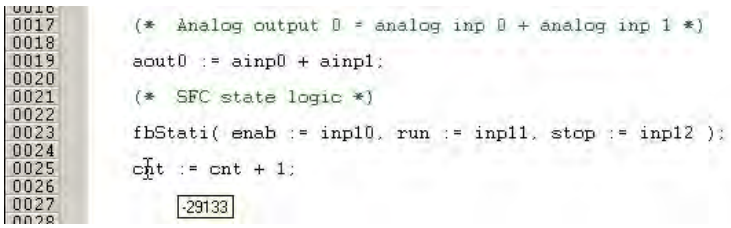
This works for both FBD and LD programming language.



Note that, once again, this tool is asynchronous.

9.4.4 IL AND ST ANIMATION

The live debug mode also applies to textual source code editors (the ones for IL and ST). You can quickly watch the values of a variable by hovering with the mouse over it.


0017 (* Analog output 0 = analog inp 0 + analog inp 1 *)
0018
0019 aout0 := ainp0 + ainp1;
0020
0021 (* SFC state logic *)
0022
0023 fbStati(enab := inp10, run := inp11, stop := inp12);
0024
0025 cnt := cnt + 1;
0026
0027
-29133

9.5 TRIGGERS

9.5.1 TRIGGER WINDOW

The *Trigger window* tool allows you to select a set of variables and to have them updated synchronously in a special pop-up window.

9.5.1.1 PRE-CONDITIONS TO OPEN A TRIGGER WINDOW

No need for special compilation

LogicLab debugging tools operate at run-time. Thus, unlike other programming languages such as C++, the compiler does not need to be told whether or not to support trigger windows: given a PLC code, the compiler's output is unique, and there is no distinction between debug and release version.

Memory availability

A trigger window takes a segment in the application code sector, having a well-defined length. Obviously, in order to start up a trigger window, it is necessary that a sufficient amount of memory is available, otherwise an error message appears.

Incompatibility with graphic trigger windows

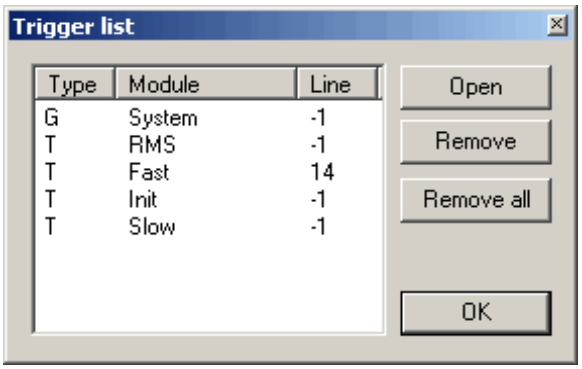
A graphic trigger window takes the whole free space of the application code sector. Therefore, once such a debugging tool has been started, it is not possible to add any trigger window, and an error message appears if you attempt to start a new window. Once the graphic trigger window is eventually closed, trigger windows are enabled again.

Note that all the trigger windows existing before the starting of a graphic trigger window keep working normally. You are simply not allowed to add new ones.

9.5.1.2 TRIGGER WINDOW TOOLBAR

Trigger window icons are part of the *Debug* toolbar and are enabled only if LogicLab is in debug mode.

Button	Command	Description
	Set/Remove trigger	In order to actually start a trigger window, select the point of the PLC code where to insert the relative trigger and then press this button. The same procedure applies to trigger window removal: in order to definitely close a debug window, click once the instruction/block where the trigger was inserted, then press this button again.
	Graphic trace	This button operates exactly as the above *Set/Remove trigger*, except for that it opens a graphic trigger window. It can be used likewise also to remove a graphic trigger window. Shortcut key: pressing *Shift + F9* is equivalent to clicking on *Set/Remove trigger* button.
	Remove all triggers	Pressing this key causes all the existing trigger windows and the graphic trigger window to be removed simultaneously. Shortcut key: pressing *Ctrl+Shift+F9* is equivalent to clicking on this button.
	Trigger list	This key opens a dialog listing all the existing trigger windows. Shortcut key: pressing *Ctrl+I* is equivalent to clicking on this button.

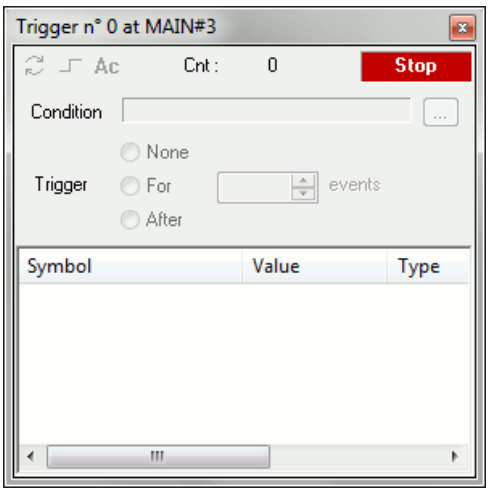


Each record refers to a trigger window, either graphic or textual. The following table explains the meaning of each field.

Field	Description
Type	*T*: trigger window. *G*: graphic trigger window.
Module	Name of the program, function, or function block where the trigger is placed. If the module is a function block, this field contains its name, not the name of its instance where you actually put the trigger.
Line	For the textual languages (IL, ST) indicates the line in which the trigger is placed. For the other languages the value is always *-1*.

9.5.1.3 TRIGGER WINDOW INTERFACE

Setting a trigger causes a pop-up window to appear, which is called *Interface* window: this is the interface to access the debugging functions that the trigger window makes available. It consists of three elements, as shown below.



Caption bar

The *Caption* bar of the pop-up window shows information on the location of the trigger which causes the refresh of the *Variables* window, when reached by the processor.

The text in the *Caption* bar has the following format:

```
Trigger n° X at ModuleName#Location
```

where

X	Trigger identifier.
ModuleName	Name of the program, function, or function block where the trigger was placed.
Location	Exact location of the trigger, within module *ModuleName*. If *ModuleName* is in IL, *Location* has the following format: N1 Otherwise, if *ModuleName* is in FBD, it becomes: N2$BT:BID where: N1 = instruction line number N2 = network number BT = block type (operand, function, function block, etc.) BID = block identifier

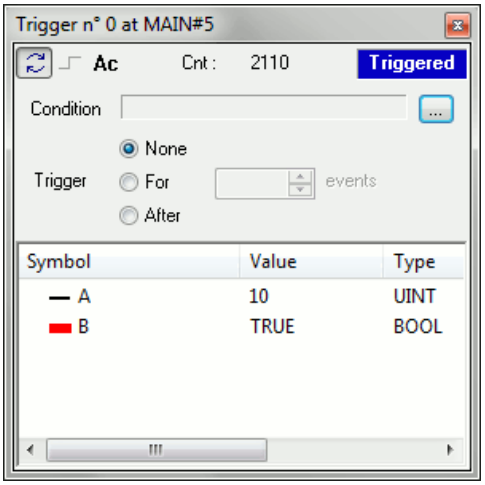
Controls section

This dialog box allows the user to better control the refresh of the trigger window to get more information on the code under scope. A detailed description of the function of each control is given in the *Trigger window* controls section (see 9.5.2.11).

All controls except *Ac*, the *Accumulator display* button, are not accessible until at least one variable is dragged into the debug window.

The Variables section

This lower section of the *Debug* window is a table consisting of a row for each variable that you dragged in. Each row has four fields: the name of the variable, its value, its type, and its location (@task:ModuleName) read from memory during the last refresh.



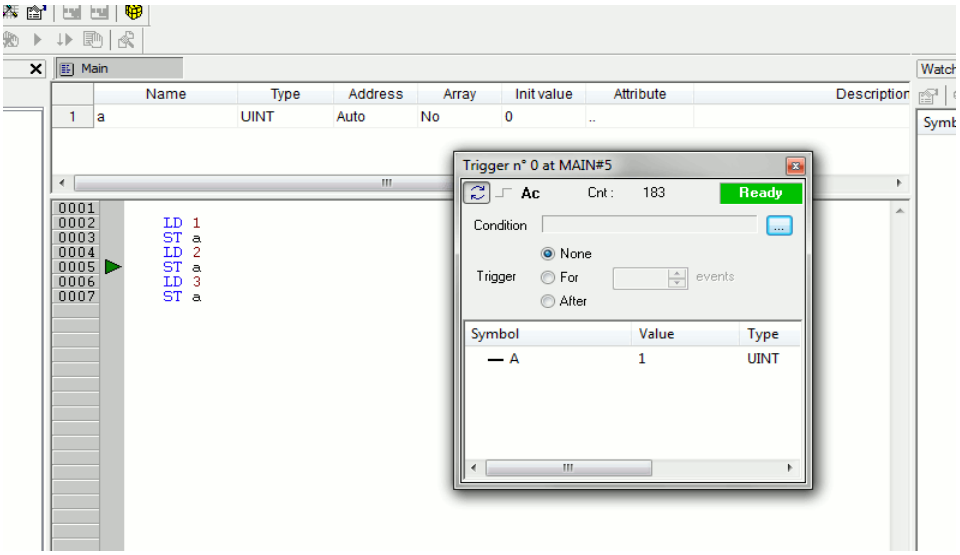
9.5.1.4 TRIGGER WINDOW: DRAG AND DROP INFORMATION

To watch a variable, you need to copy it to the lower section of the *Debug* window.

This section is a table consisting of a row for each variable you dragged in. You can drag into the trigger window only variables local to the module where you placed the relative trigger, or global variables, or parameters. You cannot drag variables declared in another program, or function, or function block.

9.5.1.5 REFRESH OF THE VALUES

Let us consider the following example.



The value of variables is refreshed every time the window manager is triggered, that is every time the processor executes the instruction marked by the green arrowhead. However, you can set controls in order to have variables refreshed only when triggers satisfy the more limiting conditions you define.

Note that the value of the variables in column *Symbol* is read from memory just before the marked instruction (in this case: the instruction at line 5) and immediately after the previous instruction (the one at line 4) has been performed.

Thus, in the above example the second ST statement has not been executed yet when the new value of *a* is read from memory and displayed in the trigger window. Thus the result of the second ST *a* is 1.

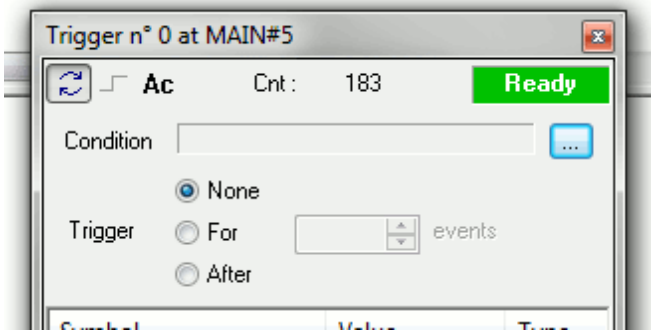
9.5.1.6 TRIGGER WINDOW CONTROLS

This paragraph deals with the trigger window controls, which allows you to better supervise the working of this debugging tool, to get more information on the code under scope.

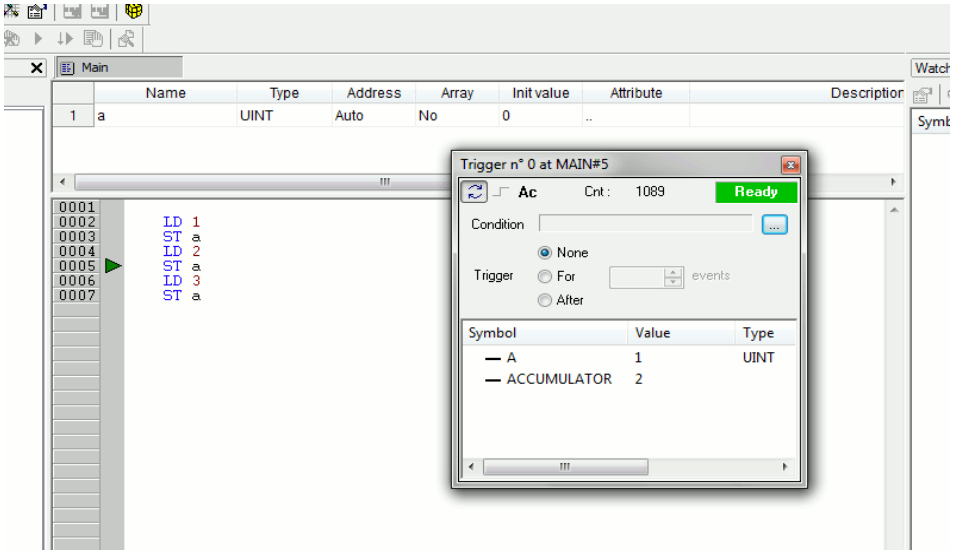
Trigger window controls act in a well-defined way on the behavior of the window, regardless for the type of the module (either IL or FBD) where the related trigger has been inserted.

All controls except the *Accumulator display* are not accessible until at least one variable is dragged into the *Variables* window.

Window controls are made accessible to users through the grey top half of the debug window.



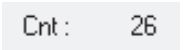
Button	Command	Description
	Start/Stop	This control is used to start a triggering session. If system is triggering you can click this button to force stop. Otherwise session automatically stops when conditions are reached. At this point you can press this button to start another triggering session.
	Single step execution	This control is used to execute a single step trigger. It is enabled only when there is no active triggering session and *None* is selected. Specified condition is considered. After the single step trigger is done, triggering session automatically stops.
	Accumulator display	This control adds the *Accumulator* to the list of variables already dragged into the trigger window. A new row is added at the bottom of the table of variables, containing the string *Accumulator* in column *Symbol*, the accumulator's value in column *Value*, *Type* is not specified and *Location* is set to global as shown in the following figure.



In order to remove the accumulator from the table, click its name in *Symbol* column, and press the *Del* key.

This control can be very useful if a trigger was inserted before a ST statement, because it allows you to know what value is being written in the destination variable, during the current execution of the task. You can get the same result by moving the trigger to an instruction following the one marked by the green arrowhead.

Trigger counter



This read-only control counts how many times the debug window manager has been triggered, since the window was installed.

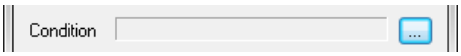
The window manager automatically resets this counter every time a new triggering session is started.

Trigger state

This read-only control shows the user the state of the *Debug* window. It can assume the following values.

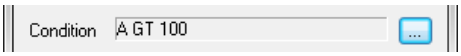
Ready	The trigger has not occurred during the current task execution.
Triggered	The trigger has occurred during the current task execution.
Stop	System is not triggering. Triggering has not been started yet or it has been stopped by user or an halt condition has been reached.
Error	Communication with target interrupted, the state of the trigger window cannot be determined.

User-defined condition

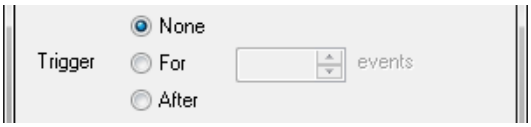


If you define a condition by using this control, the values in the *Debug* window are refreshed every time the window manager is triggered and the user-defined condition is true.

After you have entered a condition, the control displays its simplified expression.



Counters



These controls allow the user to define conditions on the trigger counter.

The trigger window can be in one of the following three states.

- *None*: no counter has been started up, thus no condition has been specified upon the trigger.
- *For*: assuming that you gave the counter limit the value N, the window manager adds *1* to the current value of the counter and refreshes the value of its variables, each time the debug window is triggered. However, when the counter equals N, the window stops refreshing the values, and it changes to the *Stop* state.
- *After*: assuming that you gave the counter limit the value N, the window manager resets the counter and adds *1* to its current value each time it is triggered. The window remains in the *Ready* state and does not update the value of its variables until the counter reaches N.

9.5.2 DEBUGGING WITH TRIGGER WINDOWS

9.5.2.1 INTRODUCTION

The trigger window tool allows the user to select a set of variables and to have their values displayed and updated synchronously in a pop-up window. Unlike the *Watch* window, trigger windows refresh simultaneously all the variables they contain, every time they are triggered.

9.5.2.2 OPENING A TRIGGER WINDOW FROM AN IL MODULE

Let us assume that you have an IL module, also containing the following instructions.

```
0001
0002    LD  a
0003    ADD b
0004    ST  a
0005
0006    LD  c
0007    ADD d
0008    ST  c
0009
0010    LD  k
0011    ADD 1
0012    ST  k
0013
```

Let us also assume that you want to know the value of b, d, and k, just before the *ST k* instruction is executed. To do so, move the cursor to line 12.

```
0009
0010    LD  k
0011    ADD 1
0012    ST  k
0013
```

Then you can click the *Set/Remove trigger* button in the *Debug* toolbar

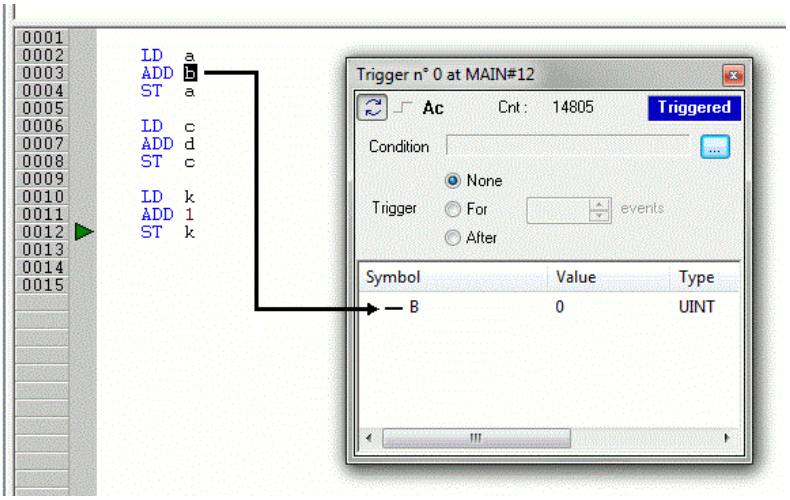
or you can press the *F9* key.

In both cases, a green arrowhead appears next to the line number, and the related trigger window pops up.

Not all the IL instructions support triggers. For example, it is not possible to place a trigger at the beginning of a line containing a JMP statement.

9.5.2.3 ADDING A VARIABLE TO A TRIGGER WINDOW FROM AN IL MODULE

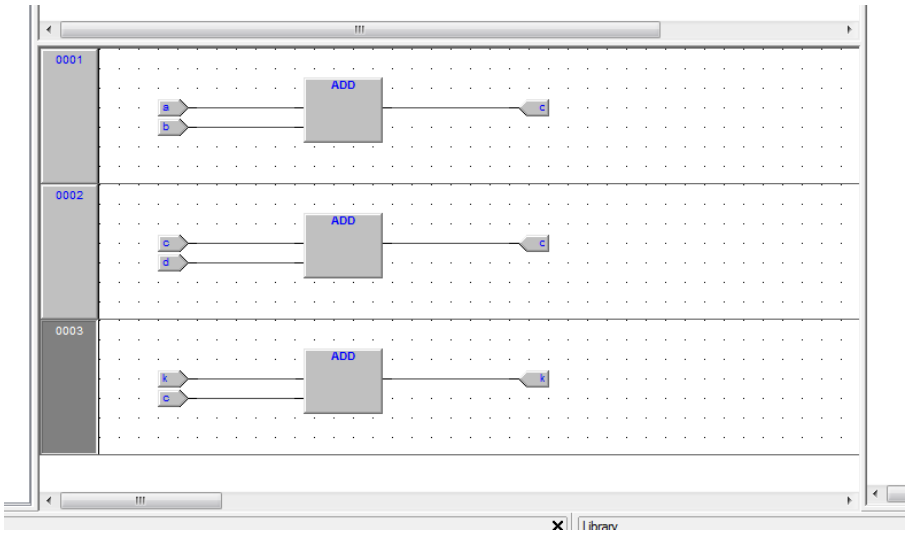
In order to watch the value of a variable, you need to add it to the trigger window. To this purpose, select a variable by double-clicking it, and then drag it into the *Variables* window, that is the lower white box in the pop-up window. The variable's name now appears in the *Symbol* column.



The same procedure applies to all the variables you wish to inspect.

9.5.2.4 OPENING A TRIGGER WINDOW FROM AN FBD MODULE

Let us assume that you have an FBD module, also containing the following instructions.



Let us also assume that you want to know the values of C, D, and K, just before the ST k instruction is executed.

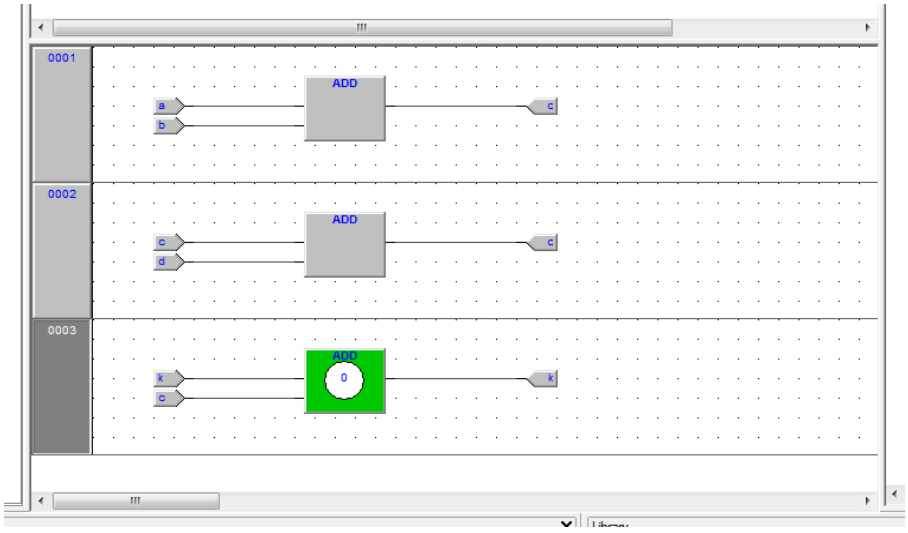
Provided that you can never place a trigger in a block representing a variable such as

you must select the first available block preceding the selected variable. In the example of the above figure, you must move the cursor to network 3, and click the ADD block.

You can click the *Set/Remove trigger* button in the *Debug* bar

or you can press the *F9* key.

In both cases, the color of the selected block turns to green, a white circle with a number inside appears in the middle of the block, and the related trigger window pops up.



When preprocessing FBD source code, the compiler translates it into IL instructions. The *ADD* instruction in network 3 is expanded to:

```
LD k
ADD 1
ST k
```

When you add a trigger to an FBD block, you actually place the trigger before the first statement of its IL equivalent code.

9.5.2.5 ADDING A VARIABLE TO A TRIGGER WINDOW FROM AN FBD MODULE

In order to watch the value of a variable, you need to add it to the trigger window. Let us assume that you want to inspect the value of variable k of the FBD code in the figure below.

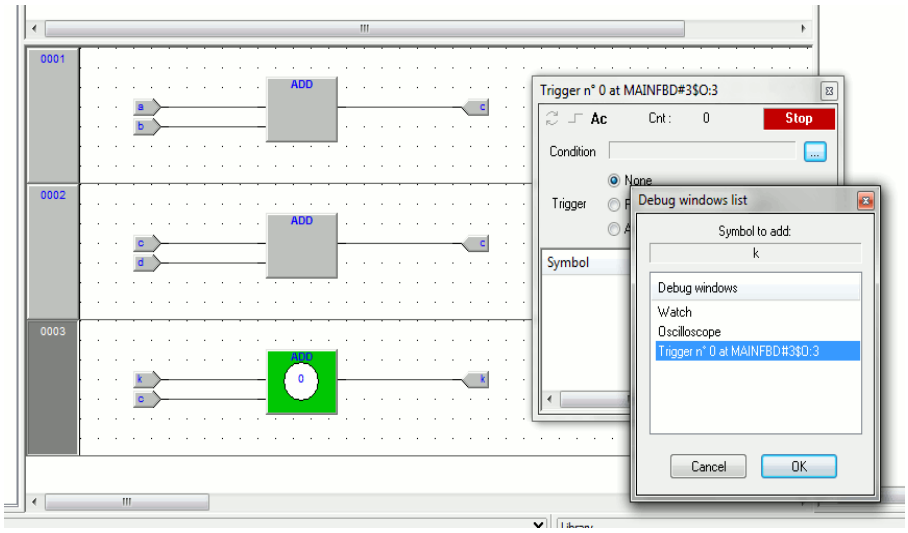
To this purpose, press the *Watch* button in the FBD bar.

The cursor will become as follows.

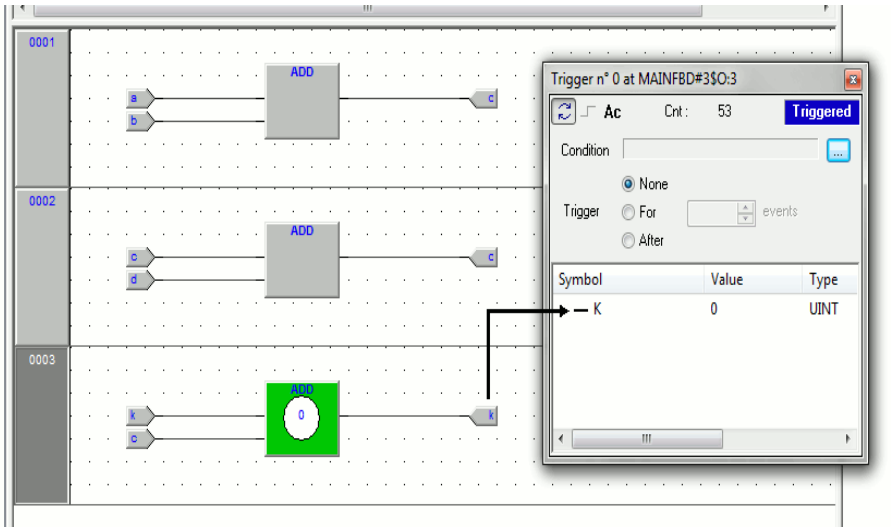
Now you can click the block representing the variable you wish to be shown in the trigger window.

In the example we are considering, click the button block.

A dialog box appears listing all the currently existing instances of debug windows, and asking you which one is to receive the object you have just clicked.



In order to display the variable k in the trigger window, select its reference in the *Debug windows* column, then press *OK*. The name of the variable is now printed in the *Symbol* column.

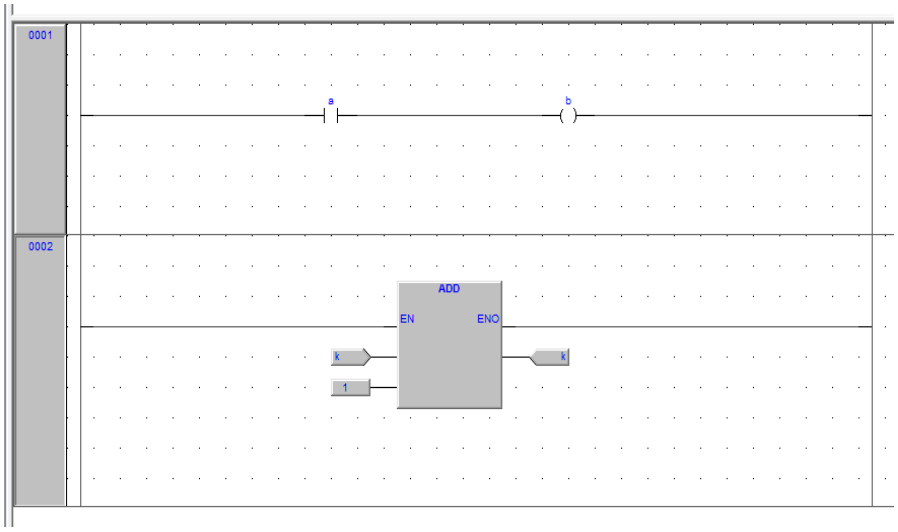


The same procedure applies to all the variables you wish to inspect.

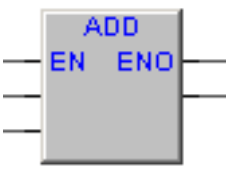
Once you have added to the *Graphic watch* window all the variables you want to observe, you can press the normal cursor button, so as to let the cursor take back its original shape.

9.5.2.6 OPENING A TRIGGER WINDOW FROM AN LD MODULE

Let us assume that you have an LD module, also containing the following instructions.



You can place a trigger on a block such as follows.



In this case, the same rules apply as to insert a trigger in an FBD module on a contact

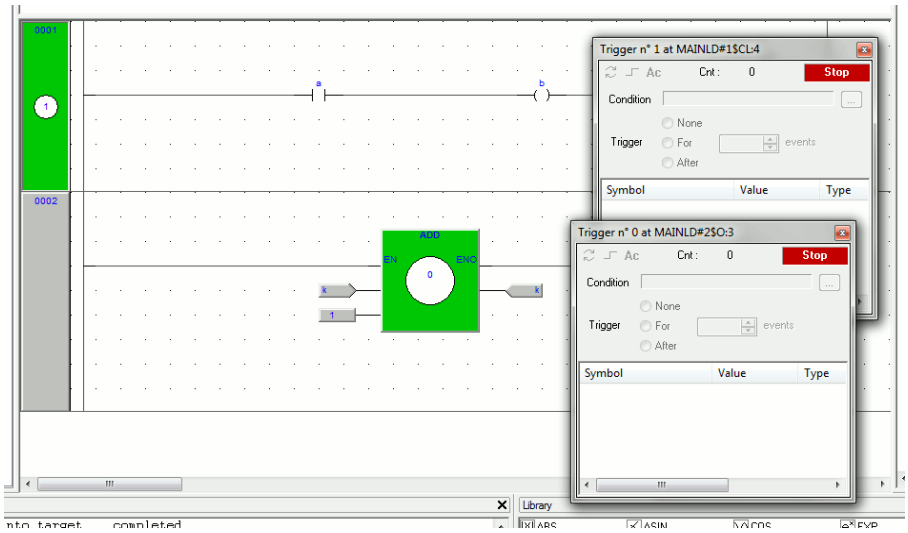
or a coil

In this case, follow the SE instructions. Let us also assume that you want to know the value of some variables every time the processor reaches network number 1.

First you must click one of the items making up network number 1. Now you can click the *Set/Remove trigger* button in the *Debug* bar.

Alternatively you can press the *F9* key.

In both cases, the grey raised button containing the network number turns to green, and a white circle with the number of the trigger inside appears in the middle of the button, while the related trigger window pops up.



Unlike the other languages supported by LogicLab, LD does not allow you to insert a trigger into a single contact or coil, as it lets you select only an entire network. Thus the variables in the trigger window will be refreshed every time the processor reaches the beginning of the selected network.

9.5.2.7 ADDING A VARIABLE TO A TRIGGER WINDOW FROM AN LD MODULE

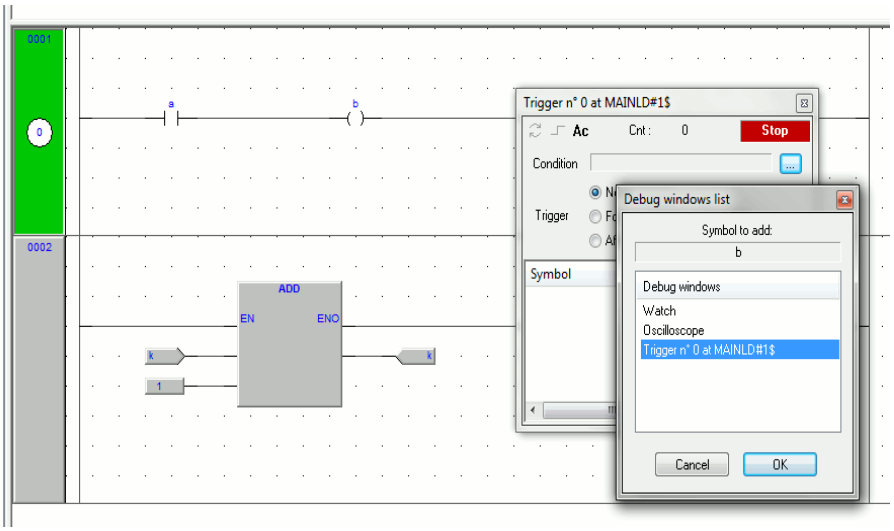
In order to watch the value of a variable, you need to add it to the trigger window. Let us assume that you want to inspect the value of variable b in the LD code represented in the figure below.

To this purpose, press the *Watch* button in the *FBD* bar.

The cursor will become as follows.

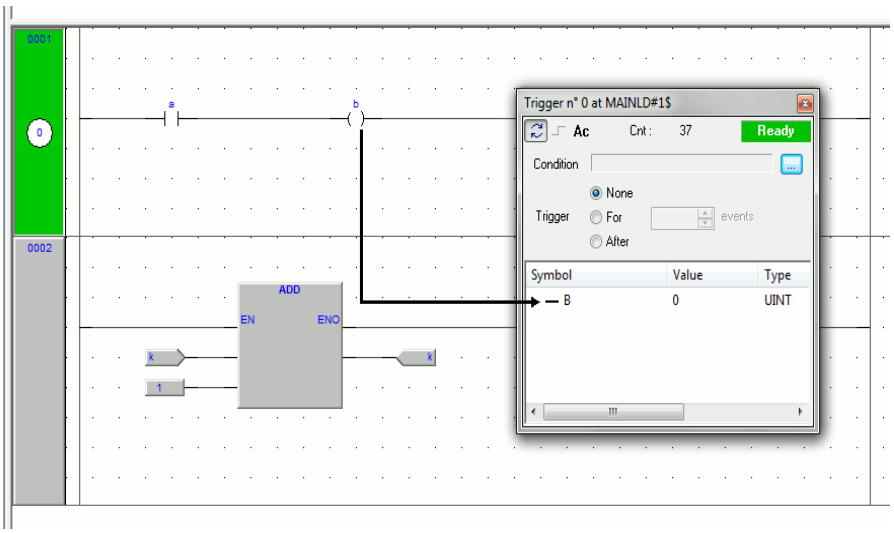
Now you can click the item representing the variable you wish to be shown in the trigger window.

A dialog box appears listing all the currently existing instances of debug windows, and asking you which one is to receive the object you have just clicked.



In order to display variable B in the trigger window, select its reference in the *Debug window* column, then press *OK*.

The name of the variable is now printed in the *Symbol* column.

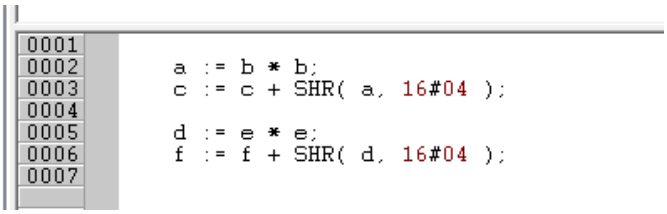


The same procedure applies to all the variables you wish to inspect.

Once you have added to the *Graphic watch* window all the variables you want to observe, you can press the *Normal cursor* button, so as to restore the original shape of the cursor.

9.5.2.8 OPENING A TRIGGER WINDOW FROM AN ST MODULE

Let us assume that you have an ST module, also containing the following instructions.



Let us also assume that you want to know the value of `e`, `d`, and `f`, just before the instruction

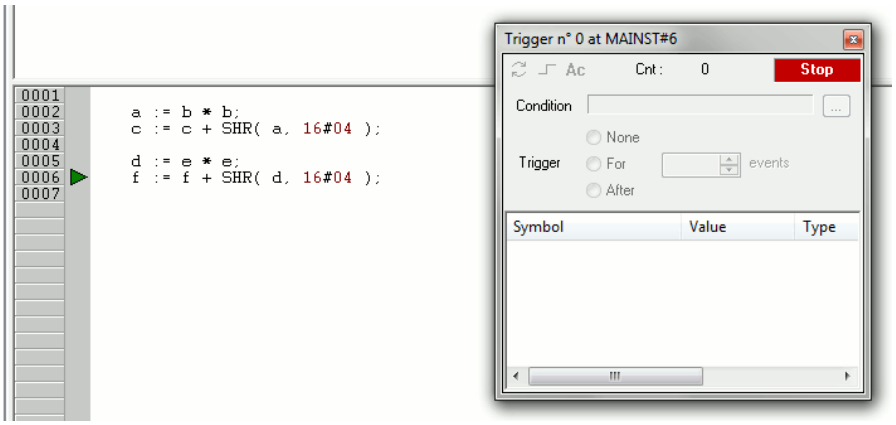
```
f := f+ SHR( d, 16#04 )
```

is executed. To do so, move the cursor to line 6.

Then you can click the *Set/Remove trigger* button in the *Debug* toolbar

or you can press the *F9* key.

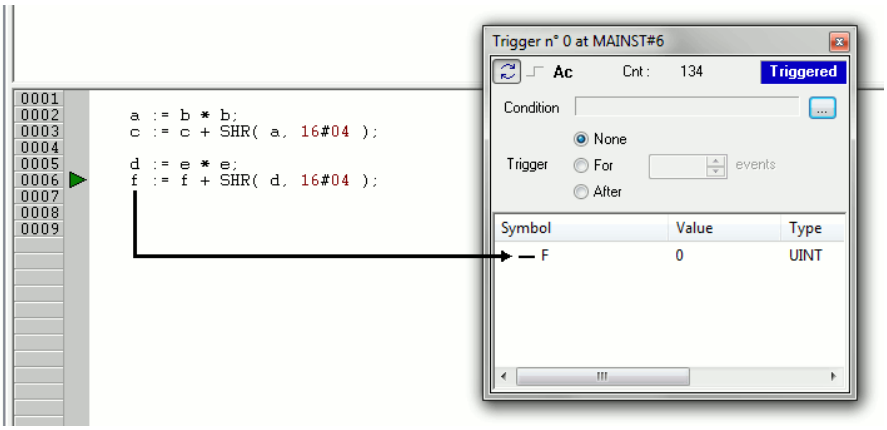
In both cases, a green arrowhead appears next to the line number, and the related trigger window pops up.



Not all the ST instructions support triggers. For example, it is not possible to place a trigger on a line containing a terminator such as `END_IF`, `END_FOR`, `END_WHILE`, etc..

9.5.2.9 ADDING A VARIABLE TO A TRIGGER WINDOW FROM AN ST MODULE

In order to watch the value of a variable, you need to add it to the trigger window. To this purpose, select a variable, by double clicking it, and then drag it into the *Variables* window, that is the lower white box in the pop-up window. The variable name now appears in the *Symbol* column.



The same procedure applies to all the variables you wish to inspect.

9.5.2.10 REMOVING A VARIABLE FROM THE TRIGGER WINDOW

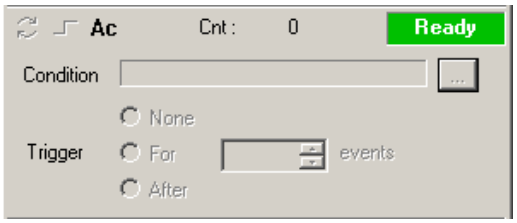
If you want a variable not to be displayed any more in the trigger window, select it by clicking its name once, then press the *Del* key.

9.5.2.11 USING CONTROLS

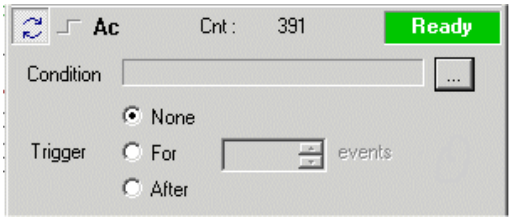
This paragraph deals with trigger windows controls, which allow you to better supervise the working of this debugging tool to get more information on the code under scope. The main purpose of trigger window controls is to let you define more limiting conditions, so that variables in *Variables* window are refreshed when the processor reaches the trigger location and these conditions are satisfied. If you do not use controls, variables are refreshed every single time the processor reaches the relative trigger.

Enabling controls

When you set a trigger, all the elements in the *Control* window look disabled.



As a matter of fact, you cannot access any of the controls, except the *Accumulator* display, until at least one variable is dragged into the *Debug* window. When this happens triggering automatically starts and the *Controls* window changes as follows.



Triggering can be started/stopped with the apposite button.

Fixing the number of refresh

If you want the values to be refreshed the first time the window is triggered, select *None*, and press the single step button, otherwise set the counter to *1* and select *For*.

If you want the values to be refreshed the first *X* times the window is triggered, set the counter to *X* and select *For*.

If you want the values to be refreshed after *Y* times the window is triggered, set the counter to *Y* and select *After*.

Triggers and conditions settings become the actual settings when the triggering is (re) started.

Watching the accumulator

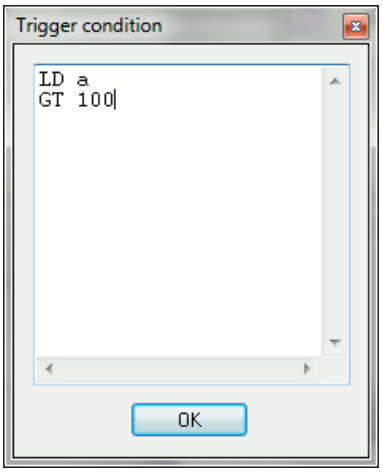
As stated in the Refresh of values section (see 9.5.1.5), when you insert a trigger on an instruction line, you establish that the variables in the relative debugging window will be updated every time the processor reaches that location, before the instruction itself is executed. In some cases, for example when a trigger is placed before a ST statement, it can be useful to know the value of the accumulator. This allows you to forecast the outcome of the instruction that will be executed after all the variables in the trigger window have been updated. To add the accumulator to the trigger window, click on the *Accumulator display* button.

Defining a condition

This control enables users to set a condition on the occurrences of a trigger. By default, this condition is set to *TRUE*, and the values in the debug window are refreshed every time the window manager is triggered.

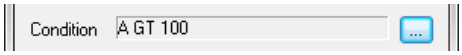
If you want to put a restriction on the refreshment mechanism, you can specify a condition by clicking on the apposite button.

When you do so, a text window pops up, where you can write the IL code that sets the condition.



Once you have finished writing the condition code, click the *OK* button to install it, or press the *Esc* button to cancel. If you choose to install it, the values in the debug window are refreshed every time the window manager is triggered and the user-defined condition is true.

A simplified expression of the condition now appears in the control.



To modify it, press again the above mentioned button.

The text window appears, containing the text you originally wrote, which you can now edit.

To completely remove a user-defined condition, delete the whole IL code in the text window, then click *OK*.

After the execution of the condition code, the accumulator must be of type Boolean (*TRUE* or *FALSE*), otherwise a compiler error occurs.

Only global variables and dragged-in variables can be used in the condition code. Namely, all variables local to the module where the trigger was originally inserted are out of scope, if they have not been dragged into the debug window. No new variables can be declared in the condition window.

9.5.2.12 CLOSING A TRIGGER WINDOW AND REMOVING A TRIGGER

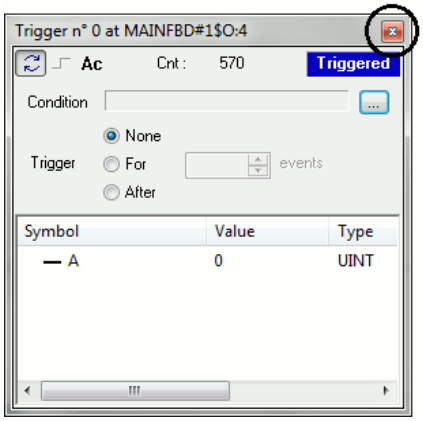
This web page deals with what you can do when you finish a debug session with a trigger window. You can choose between the following options.

- Closing the trigger window.
- Removing the trigger.
- Removing all the triggers.

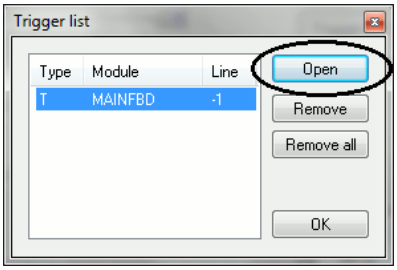
Notice that the actions listed above produce very different results.

Closing the trigger window

If you have finished watching a set of variables by means of a trigger window, you may want to close the *Debug* window, without removing the trigger. If you click the button in the top right-hand corner, you just hide the interface window, while the window manager and the relative trigger keep working.



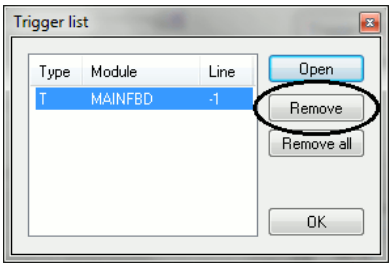
As a matter of fact, if later you want to resume debugging with a trigger window that you previously hid, you just need to open the *Trigger list* window, to select the record referred to that trigger window, and to click the *Open* button.



The interface window appears with value of variables and trigger counter updated, as if it had not been closed.

Removing a trigger

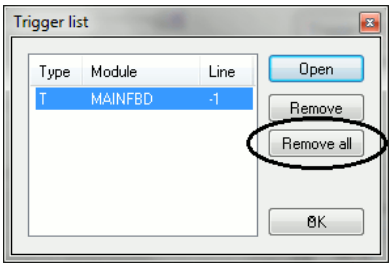
If you choose this option, you completely remove the code both of the window manager and of its trigger. To this purpose, just open the *Trigger list* window, select the record referred to the trigger window you want to eliminate, and click the *Remove* button.



Alternatively, you can move the cursor to the line (if the module is in IL or ST), or click the block (if the module is in FBD or LD) where you placed the trigger. Now press the *Set/ Remove trigger* button in the *Debug* toolbar.

Removing all the triggers

Alternatively, you can remove all the existing triggers at once, regardless for which records are selected, by clicking on the *Remove all* button.



9.6 GRAPHIC TRIGGERS

9.6.1 GRAPHIC TRIGGER WINDOW

The graphic trigger window tool allows you to select a set of variables and to have them sampled synchronously and to have their curve displayed in a special pop-up window.

Sampling of the dragged-in variables occurs every time the processor reaches the position (i.e. the instruction - if IL, ST - or the block - if FBD, LD) where you placed the trigger.

9.6.1.1 PRE-CONDITIONS TO OPEN A GRAPHIC TRIGGER WINDOW

No need for special compilation

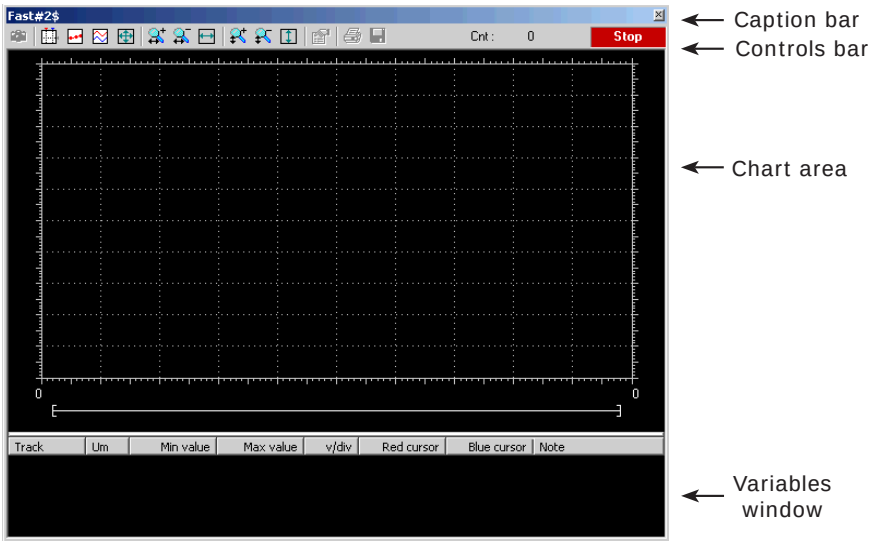
All the LogicLab debugging tools operate at run-time. Thus, unlike other programming languages such as C++, the compiler does not need to be told whether or not to support trigger windows: given a PLC code, the compiler's output is unique, and there is no distinction between debug and release version.

Memory availability

A graphic trigger window takes all the free memory space in the application code sector. Obviously, in order to start up a trigger window, it is necessary that a sufficient amount of memory is available, otherwise an error message appears.

9.6.1.2 GRAPHIC TRIGGER WINDOW INTERFACE

Setting a graphic trigger causes a pop-up window to appear, which is called *Interface* window. This is the main interface for accessing the debugging functions that the graphic trigger window makes available. It consists of several elements, as shown below.



The caption bar

The *Caption* bar at the top of the pop-up window shows information on the location of the trigger which causes the variables listed in the *Variables* window to be sampled.

The text in the caption has the following format:

```
ModuleName#Location
```

Where

`ModuleName`	Name of program, function, or function block where the trigger was placed.

`Location`	Exact location of the trigger, within module `ModuleName`.
	If `ModuleName` is in IL, ST, `Location` has the format:
	`N1`
	Otherwise, if `ModuleName` is in FBD, LD, it becomes:
	`N2$BT:BID`
	`N1` = instruction line number
	`N2` = network number
	`BT` = block type (operand, function, function block, etc.)
	`BID` = block identifier

The Controls bar

This dialog box allows you to better control the working of the graphic trigger window. A detailed description of the function of each control is given in the Graphic trigger window controls section (see 9.6.1.5).

The Chart area

The *Chart* area includes six items:

1) Plot: area containing the actual plot of the curve of the dragged-in variables.

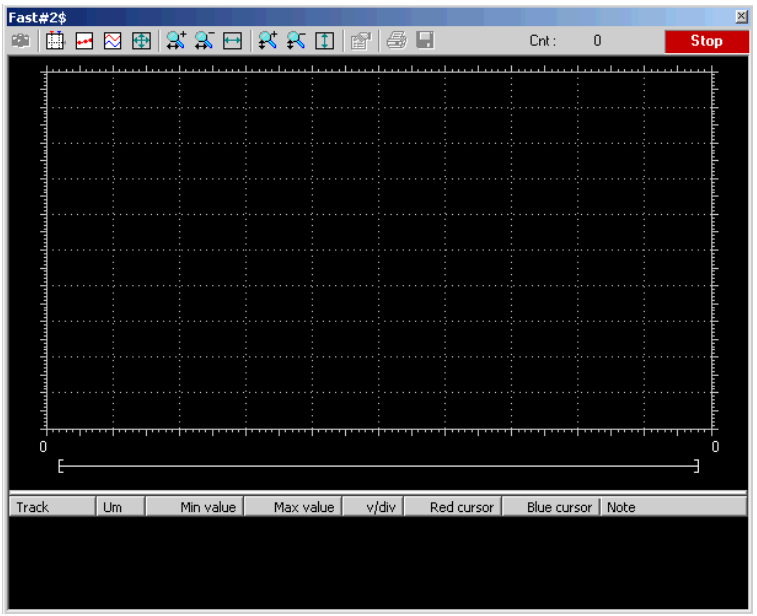
2) Samples to acquire: number of samples to be collected by the graphic trigger window manager.
3) Horizontal cursor: cursor identifying a horizontal line. The value of each variable at the intersection with this line is reported in the column *horz cursor*.
4) Blue cursor: cursor identifying a vertical line. The value of each variable at the intersection with this line is reported in the column *left cursor*.
5) Red cursor: same as blue cursor.
6) Scroll bar: if the scale of the x-axis is too large to display all the samples in the *Plot* area, the scroll bar allows you to slide back and forth along the horizontal axis.

The Variables window

This lower section of the *Debug* window is a table consisting of a row for each variable that you have dragged in. Every row has several fields, which are described in detail in the Drag and drop information section.

9.6.1.3 GRAPHIC TRIGGER WINDOW:DRAG AND DROP INFORMATION

To watch a variable, you need to copy it to the lower section of the *Debug* window.



This lower section of the *Debug* window is a table consisting of a row for each variable that you dragged in. Each row has several fields, as shown in the picture below.

Field	Description
Track	Name of the variable.
Um	Unit of measurement.
Min value	Minimum value in the record set.
Max value	Maximum value in the record set.

Field	Description
Cur value	Current value of the variable.
v/div	How many engineering units are represented by a unit of the y-axis (i.e. the space between two ticks on the vertical axis).
Blue cursor	Value of the variable at the intersection with the line identified by the blue cursor.
Red cursor	Value of the variable at the intersection with the line identified by the red cursor.
Horz cursor	Value of the variable at the intersection with the line identified by the horizontal cursor.

Note that you can drag into the graphic trigger window only variables local to the module where you placed the relative trigger, or global variables, or parameters. You cannot drag variables declared in another program, or function, or function block.

9.6.1.4 SAMPLING OF VARIABLES

Let us consider the following example.

The value of the variables is sampled every time the window manager is triggered, that is every time the processor executes the instruction marked by the green arrowhead. However, you can set controls in order to have variables sampled when triggers also satisfy further limiting conditions that you define.

The value of the variables in the column *Track* is read from memory just before the marked instruction and immediately after the previous instruction.

9.6.1.5 GRAPHIC TRIGGER WINDOW CONTROLS

This paragraph deals with controls of the *Graphic trigger* window. Controls allow you to specify in detail when LogicLab is supposed to sample the variables added to the *Variables* window.

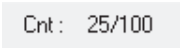
Graphic trigger window controls act in a well-defined way on the behavior of the window, regardless for the type of the module (IL, ST, FBD or LD) where the related trigger has been inserted.

Window controls are made accessible to users through the *Controls* bar of the debug window.

Button	Command	Description
	Start graphic trace	When you push this button down, you let acquisition start. Now, if acquisition is running and you release this button, you stop the sample collection process, and you reset all the data you have acquired so far.
	Enable/Disable cursors	The two cursors (red cursor, blue cursor) may be seen and moved along their axis as long as this button is pressed. Release this button if you want to hide simultaneously all the cursors.
	Show samples	This control is used to put in evidence the exact point in which the variables are triggered at each sample.

Button	Command	Description
	Split variables	When pressed, this control splits the y-axis into as many segments as the dragged-in variables, so that the diagram of each variable is drawn in a separate band.
	Show all values	It is used to fill in the graph window all the values sampled for the selected variables in the current recordset.
	Horizontal Zoom In and *Zoom Out*	Zooming in is an operation that makes the curves in the *Chart* area appear larger on the screen, so that greater detail may be viewed. Zooming out is an operation that makes the curves appear smaller on the screen, so that it may be viewed in its entirety. Horizontal zoom acts only on the horizontal axis.
	Horizontal show all	This control is used to horizontally center record set samples. So first sample will be placed on the left margin, and last will be placed on the right margin of the graphic window.
	Vertical Zoom In and *Zoom Out*	*Vertical Zoom* acts only on the vertical axis.
	Vertical show all	This control is used to vertically center record set samples. So max value sample will be placed near top margin and low value sample will be placed on the bottom margin of the graphic window.
	Graphic trigger window properties	Pushing this button causes a tabs dialog box to appear, which allows you to set general user options affecting the action of the graphic trigger window. Since the options you can set are quite numerous, they are dealt with in a section apart. Click here to access this section.
	Print chart	Push this button to print both the *Chart area* and the *Variables* window.
	Save chart	Press this button to save the chart.

Trigger counter



This read-only control displays two numbers with the following format: X/Y.

X indicates how many times the debug window manager has been triggered, since the graphic trigger was installed.

Y represents the number of samples the graphic window has to collect before stopping data acquisition and drawing the curves.

Trigger state

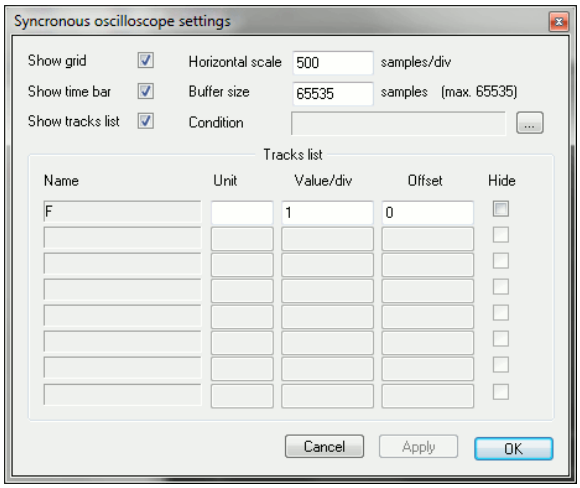
This read-only control shows you the state of the *Debug* window. It can assume the following values.

Ready	No sample(s) taken, as the trigger has not occurred during the current task execution.
Triggered	Sample(s) collected, as the trigger has occurred during the current task execution.
Stop	The trigger counter indicates that a number of samples has been collected satisfying the user request or memory constraints, thus the acquisition process is stopped.
Error	Communication with target interrupted, the state of the trigger window cannot be determined.

9.6.1.6 GRAPHIC TRIGGER WINDOW OPTIONS

In order to open the options tab, you must click the *Properties* button in the *Controls* bar. When you do this, the following dialog box appears.

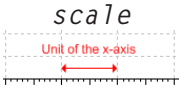
General



Control

Control	Description
Show grid	Tick this control to display a grid in the *Chart area* background.
Show time bar	The scroll bar at the bottom of the *Chart area* is available as long as this box is checked.
Show tracks list	The *Variables* window is shown as long as this box is checked, otherwise the *Chart area* extends to the bottom of the graphic trigger window.

Values

Control	Description
Horizontal scale 	Number of samples per unit of the x-axis. By unit of the x-axis the space is meant between two vertical lines of the background grid.

Control	Description
Buffer size	Number of samples to acquire. When you open the option tab, after having dragged-in all the variables you want to watch, you can read a default number in this field, representing the maximum number of samples you can collect for each variable. You can therefore type a number which is less or equal to the default one.

Tracks

This tab allows you to define some graphic properties of the plot of each variable. To select a variable, click its name in the *Track list* column.

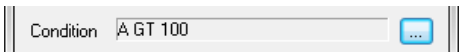
Control	Description
Unit	Unit of measurement, printed in the table of the *Variables* window.
Value/div	Δ value per unit of the y-axis. By unit of the y-axis is meant the space between two horizontal lines of the background grid.
Hide	Check this flag to hide selected track on the graph.

Push *Apply* to make your changes effective, or push *OK* to apply your changes and to close the options tab.

User-defined condition

If you define a condition by using this control, the sampling process does not start until that condition is satisfied. Note that, unlike trigger windows, once data acquisition begins, samples are taken every time the window manager is triggered, regardless of the user condition being still true or not.

After you enter a condition, the control displays its simplified expression.

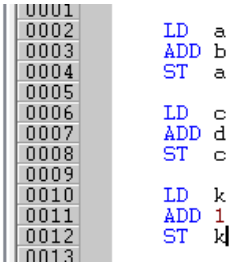


9.6.2 DEBUGGING WITH THE GRAPHIC TRIGGER WINDOW

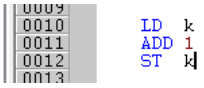
The graphic trigger window tool allows you to select a set of variables and to have them sampled synchronously and their curve displayed in a special pop-up window.

9.6.2.1 OPENING THE GRAPHIC TRIGGER WINDOW FROM AN IL MODULE

Let us assume that you have an IL module, also containing the following instructions.

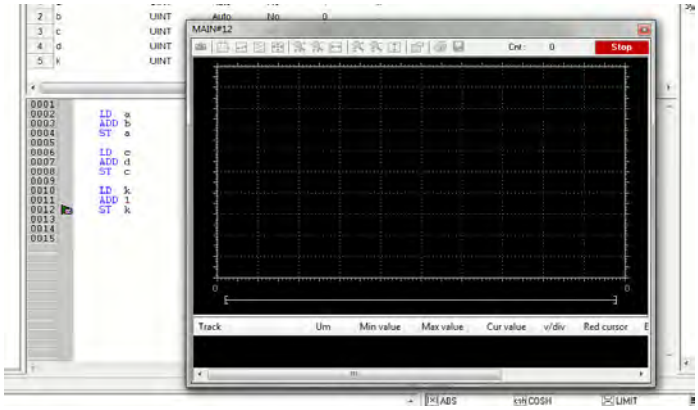


Let us also assume that you want to know the value of b, d, and k, just before the *ST k* instruction is executed. To do so, move the cursor to line 12.



Then click the *Graphic trace* button in the *Debug* toolbar.

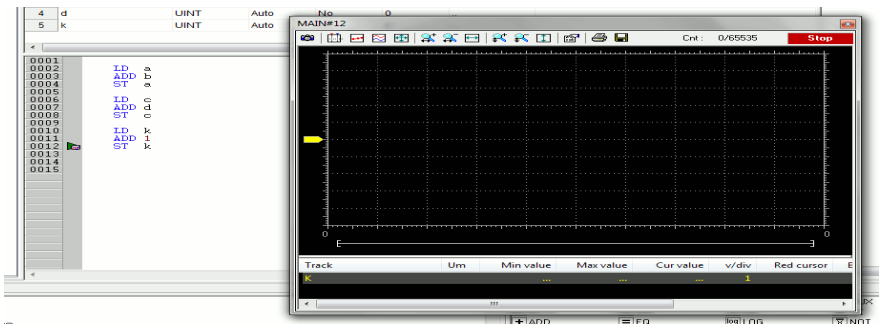
A green arrowhead appears next to the line number, and the graphic trigger window pops up.



Not all the IL instructions support triggers. For example, it is not possible to place a trigger at the beginning of a line containing a JMP statement.

9.6.2.2 ADDING A VARIABLE TO THE GRAPHIC TRIGGER WINDOW FROM AN IL MODULE

In order to get the diagram of a variable plotted, you need to add it to the graphic trigger window. To this purpose, select a variable, by double clicking it, and then drag it into the *Variables* window. The variable now appears in the *Track* column.

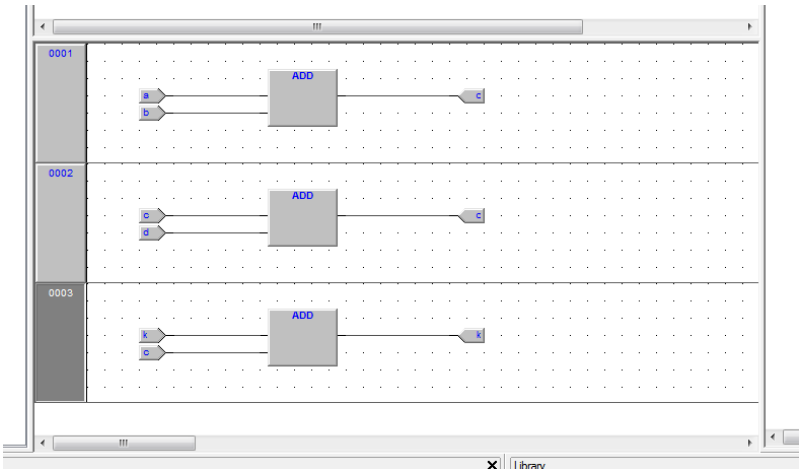


The same procedure applies to all the variables you wish to inspect.

Once the first variable is dropped into a graphic trace, the *Graphic properties* window is automatically shown and allows the user to setup sampling and visualization properties.

9.6.2.3 OPENING THE GRAPHIC TRIGGER WINDOW FORM AN FBD MODULE

Let us assume that you have an FBD module, also containing the following instructions.



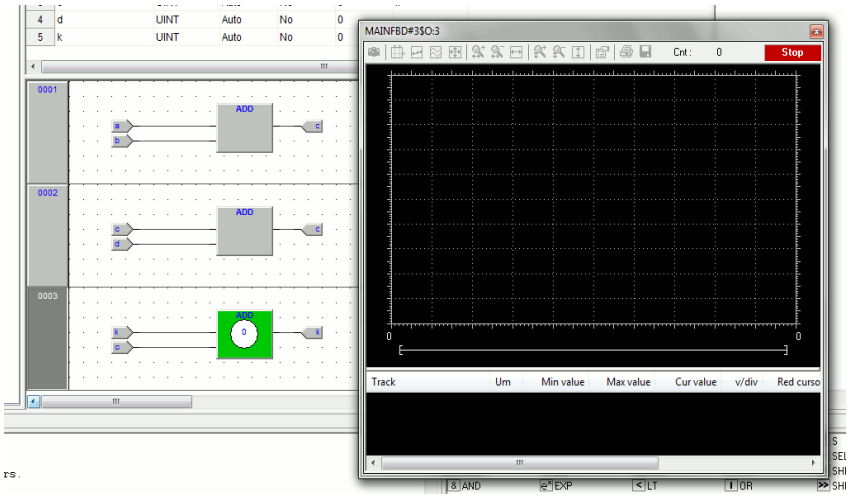
Let us also assume that you want to know the values of c, d, and k, just before the ST k instruction is executed.

Provided that you can never place a trigger in a block representing a variable such as

you must select the first available block preceding the selected variable. In the example of the above figure, you must move the cursor to network 3, and click the ADD block.

Now click the *Graphic trace* button in the *Debug* toolbar.

This causes the colour of the selected block to turn to green, a white circle with the trigger ID number inside to appear in the middle of the block, and the related trigger window to pop up.



When preprocessing the FBD source code, compiler translates it into IL instructions. The *ADD* instruction in network 3 is expanded to:

```
LD k
ADD 1
ST k
```

When you add a trigger to an FBD block, you actually place the trigger before the first statement of its IL equivalent code.

9.6.2.4 ADDING A VARIABLE TO THE GRAPHIC TRIGGER WINDOW FROM AN FBD MODULE

In order to watch the diagram of a variable, you need to add it to the trigger window. Let us assume that you want to see the plot of the variable *k* of the FBD code in the figure below.

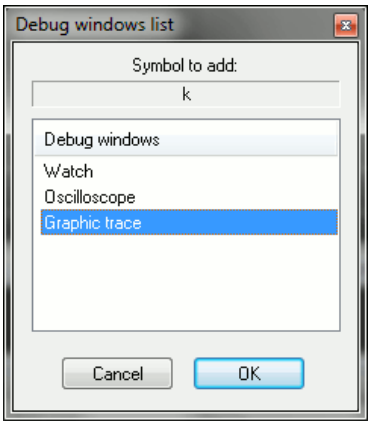
To this purpose, press the *Watch* button in the FBD bar.

The cursor will become as follows.

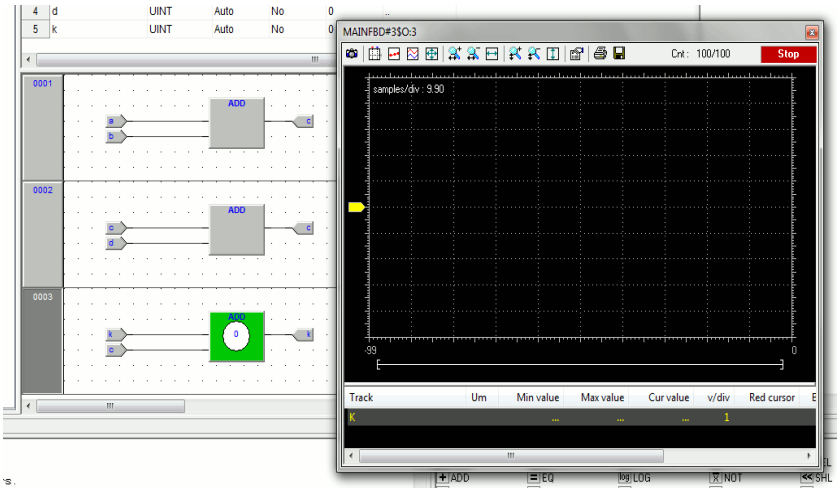
Now you can click the block representing the variable you wish to be shown in the graphic trigger window.

In the example we are considering, click the button block.

A dialog box appears listing all the currently existing instances of debug windows, and asking you which one is to receive the object you have just clicked.



In order to plot the curve of variable *k*, select *Graphic Trace* in the *Debug windows* column, then press *OK*. The name of the variable is now printed in the *Track* column.



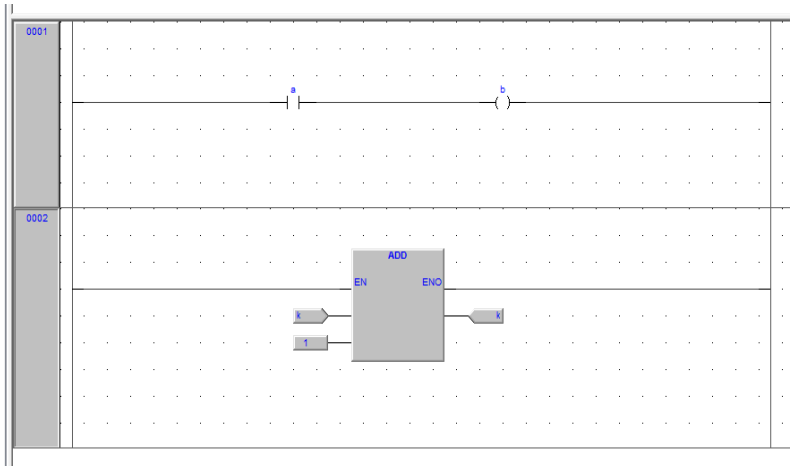
The same procedure applies to all the variables you wish to inspect.

Once you have added to the *Graphic watch* window all the variables you want to observe, you can press the *Normal cursor* button, in order to restore the original cursor.

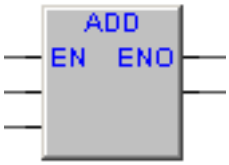
Once the first variable is dropped into a graphic trace, the *Graphic properties* window is automatically shown and allows the user to setup sampling and visualization properties.

9.6.2.5 OPENING THE GRAPHIC TRIGGER WINDOW FROM AN LD MODULE

Let us assume that you have an LD module, also containing the following instructions.



You can place a trigger on a block such as follows.



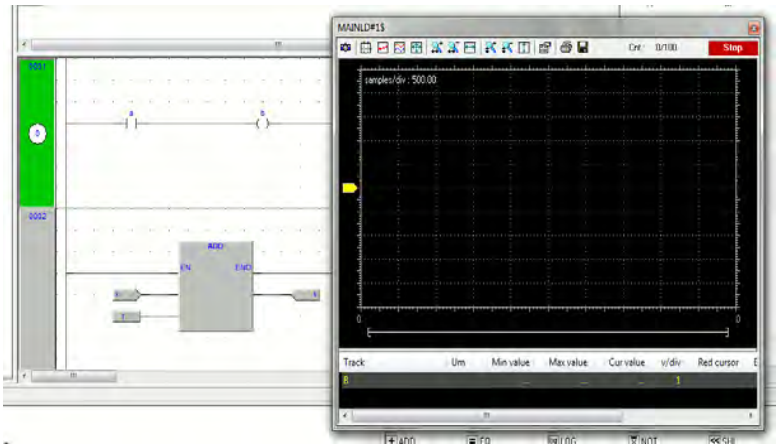
In this case, the same rules apply as to insert the graphic trigger in an FBD module on a contact

or coil

In this case, follow the instructions. Let us also assume that you want to know the value of some variables every time the processor reaches network number 1.

Click one of the items making up network nr. 1, then press the *Graphic trace* button in the *Debug* toolbar.

This causes the grey raised button containing the network number to turn to green, a white circle with a number inside to appear in the middle of the button, and the graphic trigger window to pop up.



Note that unlike the other languages supported by LogicLab, LD does not allow you to insert a trigger before a single contact or coil, as it lets you select only an entire network. Thus the variables in the *Graphic trigger* window will be sampled every time the processor reaches the beginning of the selected network.

9.6.2.6 ADDING A VARIABLE TO THE GRAPHIC TRIGGER WINDOW FROM AN LD MODULE

In order to watch the diagram of a variable, you need to add it to the *Graphic trigger* window. Let us assume that you want to see the plot of the variable b in the LD code represented in the figure below.

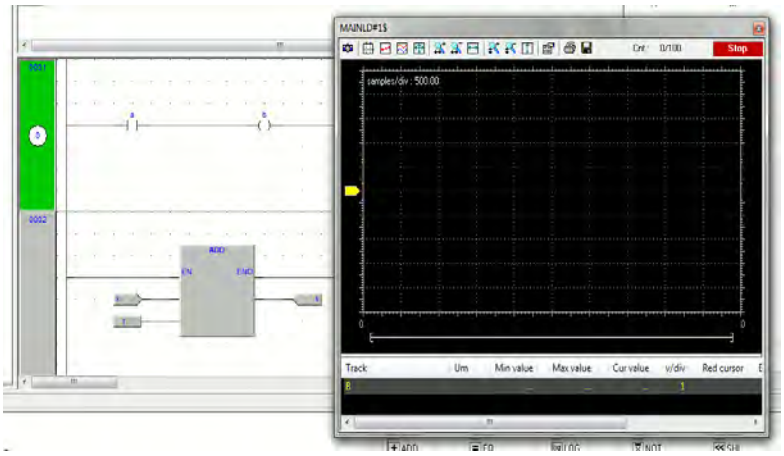
To this purpose, press the *Watch* button in the FBD bar.

The cursor will become as follows.

Now you can click the item representing the variable you wish to be shown in the *Graphic trigger* window.

A dialog box appears listing all the currently existing instances of debug windows, and asking you which one is to receive the object you have just clicked.

In order to plot the curve of variable *b*, select *Graphic trace* in the *Debug windows* column, then press *OK*. The name of the variable is now printed in the *Track* column.



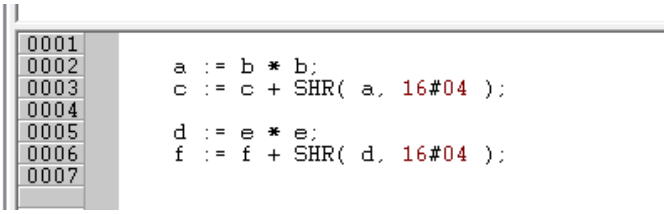
The same procedure applies to all the variables you wish to inspect.

Once you have added to the *Graphic watch* window all the variables you want to observe, you can press again the *Normal cursor* button, so as to restore the original shape of the cursor.

Once the first variable is dropped into a graphic trace, the *Graphic properties* window is automatically shown and allows the user to setup sampling and visualization properties.

9.6.2.7 OPENING THE GRAPHIC TRIGGER WINDOW FROM AN ST MODULE

Let us assume that you have an ST module, also containing the following instructions.



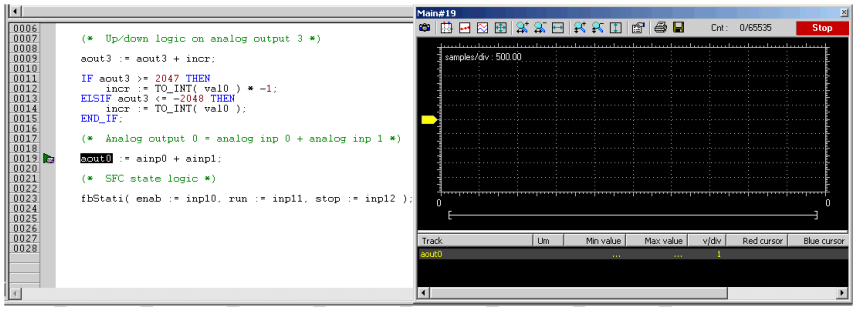
Let us also assume that you want to know the value of `e`, `d`, and `f`, just before the instruction

```
f := f+ SHR( d, 16#04 )
```

is executed. To do so, move the cursor to line 6.

Then click the *Graphic trace* button in the *Debug* toolbar.

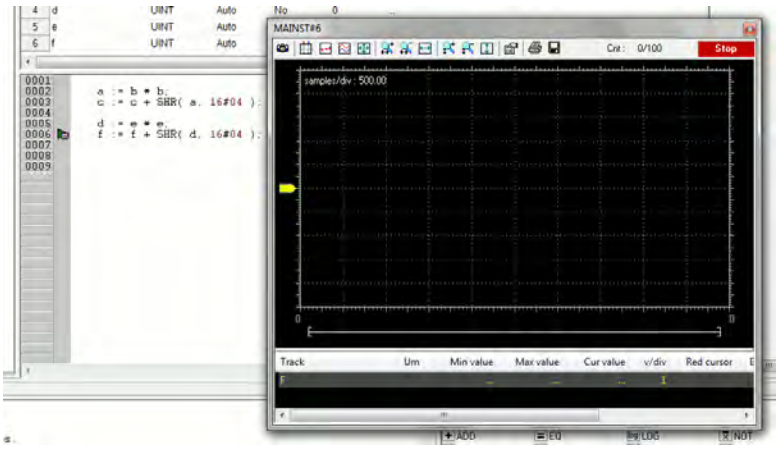
A green arrowhead appears next to the line number, and the *Graphic trigger* window pops up.


(* Up/down logic on analog output 3 *)
aout3 := aout3 + incr;
IF aout3 >= 2047 THEN
incr := TO_INT(val0) * -1;
ELSIF aout3 <= -2048 THEN
incr := TO_INT(val0);
END_IF;
(* Analog output 0 = analog inp 0 + analog inp 1 *)
aout0 := ainp0 + ainp1;
(* SFC state logic *)
fbStati(enab := inp10, run := inp11, stop := inp12);
Main#19
Stop
samples/div : 500.00
Track
Um
Min value
Max value
v/div
Red cursor
Blue cursor

Not all the ST instructions support triggers. For example, it is not possible to place a trigger on a line containing a terminator such as `END_IF`, `END_FOR`, `END_WHILE`, etc.

9.6.2.8 ADDING A VARIABLE TO THE GRAPHIC TRIGGER WINDOW FROM AN ST MODULE

In order to get the diagram of a variable plotted, you need to add it to the *Graphic trigger* window. To this purpose, select a variable, by double clicking it, and then drag it into the *Variables* window, that is the lower white box in the pop-up window. The variable now appears in the *Track* column.



The same procedure applies to all the variables you wish to inspect.

Once the first variable is dropped into a graphic trace, the *Graphic properties* window is automatically shown and allows the user to setup sampling and visualization properties.

9.6.2.9 REMOVING A VARIABLE FROM THE GRAPHIC TRIGGER WINDOW

If you want to remove a variable from the Graphic trigger window, select it by clicking its name once, then press the *Del* key.

9.6.2.10 USING CONTROLS

This paragraph deals with graphic trigger window controls, which allow you to better supervise the working of this debugging tool, so as to get more information on the code under scope.

Enabling controls

When you set a trigger, all the elements in the *Control* bar are enabled. You can start data acquisition by clicking the *Start graphic trace acquisition* button.

If you defined a user condition, which is currently false, data acquisition does not start, even though you press the apposite button.

On the contrary, once the condition becomes true, data acquisition starts and continues until the *Start graphic trace acquisition* button is released, regardless for the condition being or not still true.

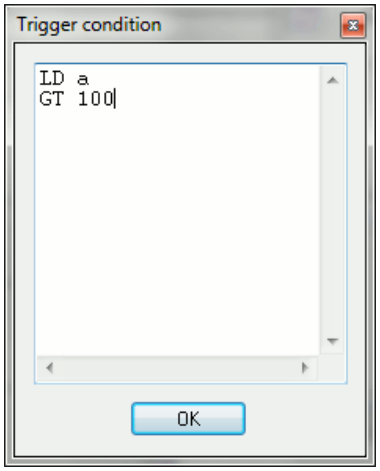
if you release the *Start graphic trace acquisition* button before all the required samples have been acquired, the acquisition process stops and all the collected data get lost.

Defining a condition

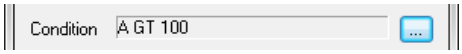
This control enables users to set a condition on when to start acquisition. By default, this condition is set to true, and acquisition begins as soon as you press the *Enable/Disable acquisition* button. From that moment on, the value of the variables in the *Debug* window is sampled every time the trigger occurs.

In order to specify a condition, open the *Condition* tab of the *Options* dialog box, then press the relevant button.

A text window pops up, where you can write the IL code that sets the condition.



Once you have finished writing the condition code, click the *OK* button to install it, or press the *Esc* button to cancel. The collection of samples will not start until the *Start graphic trace acquisition* button is pressed and the user-defined condition is true. A simplified expression of the condition now appears in the control.



To modify it, press again the relevant button.

The text window appears, containing the text you originally wrote, which you can now edit.

To completely remove a user-defined condition, press again on the above mentioned button, delete the whole IL code in the text window, then click *OK*.

After the execution of the condition code, the accumulator must be of type Boolean (*TRUE* or *FALSE*), otherwise a compiler error occurs.

Only global variables and dragged-in variables can be used in the condition code. Namely, all variables local to the module where the trigger was originally inserted are out of scope, if they have not been dragged into the *Debug* window. Also, no new variables can be declared in the condition window.

Setting the scale of axes

- x-axis

When acquisition is completed, LogicLab plots the curve of the dragged-in variables adjusting the x-axis so that all the data fit in the the *Chart* window. If you want to apply a different scale, open the *General* tab of the *Graph properties* dialog box, type a number in the horizontal scale edit box, then confirm by clicking *Apply*.

- y-axis

You can change the scale of the plot of each variable through the *Tracks list* tab of the *Graph properties* dialog box. Otherwise, if you do not need to specify exactly a scale, you can use the *Zoom In* and *Zoom Out* controls.

9.6.2.11 CLOSING THE GRAPHIC TRIGGER WINDOW AND REMOVING THE TRIGGER

At the end of a debug session with the graphic trigger window you can choose between the following options:

- Closing the *Graphic trigger* window.
- Removing the trigger.
- Removing all the triggers.

Closing the graphic trigger window

If you have finished plotting the diagram of a set of variables by means of the *Graphic trigger* window, you may want to close the *Debug* window without removing the trigger. If you click the button in the top right-hand corner, you just hide the *Interface* window, while the window manager and the relative trigger keep working.

As a matter of fact, if later you want to restore the *Graphic trigger* window that you previously hid:

- open the *Trigger list* window;
- select the record (having type *G*);
- click the *Open* button.

The *Interface* window appears with the trigger counter properly updated, as if it had never been closed.

Removing the trigger

If you choose this option, you completely remove the code both of the window manager and of its trigger. To this purpose:

- open the *Trigger list* window;
- select the record (having type G);
- click the *Remove* button.

Alternatively, you can move the cursor to the line (if the module is in IL), or click the block (if the module is in FBD) where you placed the trigger. Now press the *Graphic trace* button in the *Debug* toolbar.

Removing all the triggers

Alternatively, you can remove all the existing triggers at once, regardless for which records are selected, by clicking on the *Remove all triggers* button.

10. LOGICLAB REFERENCE

10.1 MENUS REFERENCE

In the following tables you can see the list of all LogicLab's commands. However, since LogicLab has a multi-document interface (MDI), you may find some disabled commands or even some unavailable menus, depending on what kind of document is currently active.

10.1.1 FILE MENU

Command	Description
New project	Lets you create a new LogicLab project.
Open project	Lets you open an existing LogicLab project.
View project	Opens an existing LogicLab project in read-only mode.
Save project	Same as *Save all*, but it saves also the *ppj* file. Note that, since all modifications to a LogicLab project are first applied in memory only, you need to release the *Save project* command to make them permanent.
Save project As	Asks you to specify a new project name and a new location, and saves there a copy of all the files of the project.
Close project	Asks you whether you want to keep unsaved changes, then closes the active project.
New text file	Opens a blank new generic text file.
Open file	Opens an existing file, whatever its extension. The file is displayed in the text editor. Anyway, if you open a project file, you actually open the LogicLab project it refers to.
Save	Lets you save the document in the currently active window.
Close	Closes the document in the currently active window.
Options	Opens the *Programming environment options* dialog box.
Print	Displays a dialog box, which lets you set printing options and print the document in the currently active window.
Print preview	Shows a picture on your video, that reproduces faithfully what you get if you print the document in the currently active window.
Print project	Prints all the documents making up the project.
Printer setup	Opens the *Printer setup* dialog box.
..recent..	Lists a set of *ppj* file of recently opened LogicLab projects. Click one of them, if you want to open the relevant project.
Exit	Closes LogicLab.

10.1.2 EDIT MENU

Command	Description
Undo	Cancels last change made in the document.
Redo	Restores the last change canceled by *Undo*.
Cut	Removes the selected items from the active document and stores them in a system buffer.
Copy	Copies the selected items to a system buffer.
Paste	Pastes in the active document the contents of the system buffer.
Delete	Deletes the selected item.
Delete line	Deletes the whole source code line.
Find in project	Opens the *Find in project* dialog box.
Bookmarks	Lets you set, remove, and move between bookmarks.
Go to line	Allows you to quickly move to a specific line in the source code editor.
Find	Asks you to type a string and searches for its first instance within the active document from the current location of the cursor.
Find next	Iterates the search previously performed by the *Find* command.
Replace	Allows you to automatically replace one or all the instances of a string with another string.
Insert/Move mode	Editing mode which allows you to insert and move blocks.
Connection mode	Editing mode which allows you to draw logical wires to connect pins.
Watch mode	Editing mode which allows you to add variables to any debugging tool.

10.1.3 VIEW MENU

Command	Description
Main Toolbar	If checked, displays the *Main* toolbar, otherwise hides it.
Status bar	If checked, displays the *Status* bar, otherwise hides it.
Debug bar	If checked, displays the *Debug* bar, otherwise hides it.
FBD bar	If checked, displays the *FBD* toolbar, otherwise hides it.
LD bar	If checked, displays the *LD* toolbar, otherwise hides it.
SFC bar	If checked, displays the *SFC* bar, otherwise hides it.
Project bar	If checked, displays the *Project* bar, otherwise hides it.
Network	If checked, displays the *Network* toolbar, otherwise hides it.
Document bar	If checked, displays the *Document* bar, otherwise hides it.
Force I/O bar	If checked, displays the *Force I/O* bar, otherwise hides it.
Workspace	If checked, displays the *Workspace* (also called *Project* window), otherwise hides it.
Library	If checked, displays the *Libraries* window, otherwise hides it.

Command	Description
Output	If checked, displays the *Output* window, otherwise hides it.
Async Graphic window	If checked, displays the *Oscilloscope* window, otherwise hides it.
Watch window	If checked, displays the *Watch* window, otherwise hides it.
Full screen	Expands the currently active document window to full screen. Press *Esc* to restore the normal appearance of the LogicLab interface.
Grid	If checked, displays a dotted grid in a graphical source code editor background.

10.1.4 PROJECT MENU

Command	Description
New object	Opens another menu which lets you create a new POU or declare a new global variable.
Copy object	Copies the object currently selected in the Workspace.
Paste object	Pastes the previously copied object.
Duplicate object	Duplicates the object currently selected in the Workspace, and asks you to type the name of the copy.
Delete object	Deletes the currently selected object. As explained above, you need to release the *Save project* command to definitively erase a document from your project.
PLC object properties	Shows properties and description of the object currently selected in the Workspace.
Object browser	Opens the *Oject browser*, which lets you navigate between objects.
Compile	Asks you whether to save unsaved changes, then launches the LogicLab compiler.
Recompile all	Recompiles the project.
Generate redistributable source module	Generates an RSM file.
Import object from library	Lets you import a LogicLab object from a library.
Export object to library	Lets you export a LogicLab object to a library.
Library manager	Opens the *Library manager*.
Macros	Opens another menu which lets you create/delete macros.
Select target	Lets you change the target.
Options...	Lets you specify the project options.

10.1.5 DEBUG MENU

Command	Description
Add symbol to watch	Adds a symbol to the *Watch* window.
Insert new item into watch	Inserts a new item into the *Watch* window.
Add symbol to a debug window	Adds a symbol to a debug window.
Insert new item into a debug window	Inserts a new item into a debug window.
Quick watch	Opens a dialog with the actual value of the variable.
Run	Restarts program after a breakpoint is hit.
Add/Remove breakpoint	Adds/removes a breakpoint.
Remove all breakpoints	Removes all the active breakpoints.
Breakpoint list	Lists all the active breakpoints.
Add/remove text trigger	Adds/removes a text trigger.
Add/remove graphic trigger	Adds/removes a graphic trigger.
Remove all triggers	Removes all the active triggers.
Trigger list	Lists all the active triggers.
Debug mode	Switches the debug mode on.
Live debug mode	Switches the live debug mode on.

10.1.6 COMMUNICATION MENU

Command	Description
Download code	LogicLab checks if any changes have been applied since last compilation, and compiles the project if this is the case. Then, it sends the target the compiled code.
Connect	LogicLab tries to establish a connection to the target.
Settings	Lets you set the properties of the connection to the target.
Upload IMG file	If the target device is connected, lets you upload the *img* file.
Start/Stop watch value	Freezes/resumes refreshment of the *Watch* window.

10.1.7 SCHEME MENU

Command	Description
Network> New> Top	Adds a blank network at the top of the active LD/FBD document.
Network> New> Bottom	Adds a blank network at the bottom of the active LD/FBD document.
Network> New> Before	Adds a blank network before the selected network in the active LD/FBD document.
Network >New > After	Adds a blank network after the selected network in the active LD/FBD document.
Network >Label	Assigns a label to the selected network, so that it can be indicated as the target of a jump instruction.
Object >New	Lets you insert a new object into the selected network.
Object > Instance name	Lets you assign a name to an instance of a function block, that you have previously selected by clicking it once.
Object > Open source	Opens the editor by which the selected object was created, and displays the relevant source code: - if the object is a program, or a function, or a function block, this command opens its source code; - if the object is a variable or a parameter, this command opens the corresponding variable editor; - if the object is a standard function or an operator, this command opens nothing.
Auto connect	If checked, enables autoconnection, that is automatic creation of a logical wire linking the pins of two blocks, when they are brought close.
Delete invalid connection	Removes all invalid connections, represented by a red line in the active scheme.
Increment pins	By default some operators like *ADD*, *MUL*, etc. have two input pins, however you may occasionally need to perform such operations on more than two operands. This command allows you to add as many input pins as to reach the required number of operands.
Decrement pins	Undoes the *Increment pins* command.
Enable EN/ENO pins	Adds the *enable in/enable out* pins to the selected block. The code implementing the selected block will be executed only when the *enable in* signal is true. The *enable out* signal simply repeats the value of *enable in*, allowing you either to enable or to disable a set of blocks in cascade.
Object properties	Shows some properties of the selected block: - if the object is a function or a function block, displays a table with the input and output variables; - if the object is a variable or a parameter, opens a dialog box which lets you change the name and the logical direction (input/output).

10.1.8 VARIABLES MENU

Command	Description
Insert	Adds a new row to the table in the currently active editor (if PLC editor, to the table of local variables; if parameters editor, to the table of parameters, etc.).
Delete	Deletes the variable in the selected row of the currently active table.
Group	Opens a dialog box which lets you create and delete groups of variables.

10.1.9 DEFINITIONS MENU

Command	Description
Insert> Enum	Creates a new enumerated data type.
Insert> Structure	Creates a new structured data type.
Insert> Subrange	Creates a new subrange data type.
Insert> Typedef	Creates a new typedef data type.

10.1.10 WINDOW MENU

Command	Description
Cascade	Displaces all open documents in cascade, so that they completely overlap except for the caption.
Tile	The PLC editors area is split into frames having the same dimensions, depending on the number of currently open documents. Each frame is automatically assigned to one of such documents.
Arrange Icons	Displaces the icons of the minimized documents in the bottom left-hand corner of the PLC editors area.
Close all	Closes all open documents.

10.1.11 HELP MENU

Command	Description
Index	Lists all the *Help keywords* and opens the related topic.
Context	Context-sensitive help. Opens the topic related to the currently active window.
About...	Information on producers and version.

10.2 TOOLBARS REFERENCE

In the following tables you can see the list of all LogicLab's toolbars. The buttons making up each toolbar are always the same, whatever the currently active document. However, some of them may produce no effect, if there is no logical relation to the active document.

10.2.1 MAIN TOOLBAR

Button	Command	Description
	New project	Creates a new project.
	Open project	Opens an existing project.
	Save project	Saves all documents in the currently open windows, including the project file. Note that, since all modifications to a LogicLab project are first applied in memory only, you need to release the *Save project* command to make them permanent.
	Undo	Cancels last change made in the document.
	Redo	Restores the last change canceled by *Undo*.
	Cut	Removes the selected items from the active document and stores them in a system buffer.
	Copy	Copies the selected items to a system buffer.
	Paste	Pastes in the active document the contents of the system buffer.
	Find	Asks you to type a string and searches for its first instance within the active document from the current location of the cursor.
	Find next	Iterates the search previously performed by the *Find* command.
	Find in project	Opens the *Find in project* dialog box.
	Print	Displays a dialog box, which lets you set printing options and print the document in the currently active window.
	Print preview	Shows a picture on your video, that reproduces faithfully what you get if you print the document in the currently active window.
	Workspace	If pressed, displays the Workspace (also called *Project* window), otherwise hides it.
	Output	If pressed, displays the *Output* window, otherwise hides it.
	Library	If pressed, displays the *Libraries* window, otherwise hides it.

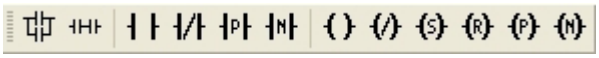
Button	Command	Description
	Watch	If checked, displays the *Watch* window, otherwise hides it.
	Async	If checked, displays the *Oscilloscope* window, otherwise hides it.
	Force I/O	If pressed, displays the *Force I/O* window, otherwise hides it.
	PLC run-time monitor	If checked, displays the PLC run-time window, otherwise hides it.
	Full screen	Expands the currently active document window to full screen. Press *Esc* or release the *Full screen* button to restore the normal appearance of the LogicLab interface.

10.2.2 FBD TOOLBAR

Button	Command	Description
	Move/Insert	Editing mode which allows you to insert and move blocks.
	Connection	Editing mode which allows you to draw logical wires to connect pins.
	Watch	Editing mode which allows you to add variables to any debugging tool.
	New block	Lets you insert a new block into the selected network.
	Constant	Adds a constant to the selected network.
	Return	Adds a conditional return block to the selected network.
	Jump	Adds a conditional jump block to the selected network.
	Comment	Adds a comment to the selected network.
	Inc pins	By default some operators like *ADD*, *MUL*, etc. have two input pins, however you may occasionally need to perform such operations on more than two operands. This command allows you to add as many input pins as to reach the required number of operands.
	Dec pins	Undoes the *Inc pins* command.

Button	Command	Description
	EN/ENO	Adds the *enable in/enable out* pins to the selected block. The code implementing the selected block will be executed only when the *enable in* signal is true. The *enable out* signal simply repeats the value of *enable in*, allowing you either to enable or to disable a cascade of blocks.
	FBD properties	Shows some properties of the selected block: - if the object is a function or a function block, displays a table with the input and output variables; - if the object is a variable or a parameter, opens a dialog box which lets you change the name and the logical direction (input/output).
	View source	Opens the editor by which the selected object was created, and displays the relevant source code: - if the object is a program, or a function, or a function block, this command opens the relevant source code editor; - if the object is a variable or a parameter, then this command opens the corresponding variable editor; - if the object is a standard function or an operator, this command opens nothing.

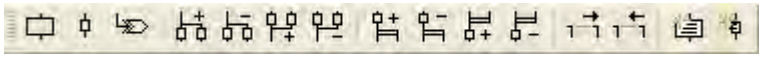
10.2.3 LD TOOLBAR



Button	Command	Description
	Insert parallel	Activates the parallel insertion mode. All contacts inserted in this mode will be inserted in parallel with the actually selected contacts.
	Insert series	Activates the series insertion mode. All contacts inserted in this mode will be inserted on the right of the currently selected contact/block. If a connection is selected, the new contact will be placed in the middle of the connection segment.
	Insert contact	Insertion of a new contact according to the selected mode (series or parallel).
	Insert negated contact	Insertion of a new negative contact according to the selected mode (series or parallel).
	Insert rising edge contact	Insertion of a new rising edge contact according to the selected mode (serial or parallel).
	Insert falling edge contact	Insertion of a new falling edge contact according to the selected mode (serial or parallel).
	Insert coil	Insertion of a new coil attached to the right power rail.

Button	Command	Description
	Insert negated coil	Insertion of a new negative coil attached to the right power rail.
	Insert set contact	Insertion of a new set coil attached to the right power rail.
	Insert reset coil	Insertion of a new reset coil attached to the right power rail.
	Insert rising edge contact	Insert positive transition-sensing coil to the right power rail.
	Insert falling edge contact	Insert negative transition-sensing coil to the right power rail.

10.2.4 SFC TOOLBAR



Button	Command	Description
	New step	Inserts a new step into the currently open SFC document.
	Add transition	Adds a new transition to the currently open SFC document.
	Add jump	Adds a new jump block to the currently open SFC document.
	Add divergent pin	Adds a new pin to the selected divergent transition.
	Remove divergent pin	Removes the rightmost pin from the selected divergent transition.
	Add convergent pin	Adds a new pin to the selected convergent transition.
	Remove convergent pin	Removes the rightmost pin from the selected convergent transition.
	Add simultaneous divergent pin	Adds a new pin to the selected simultaneous divergent transition.
	Remove simultaneous divergent pin	Removes the rightmost pin from the selected simultaneous divergent transition.
	Add simultaneous convergent pin	Adds a new pin to the selected simultaneous convergent transition.
	Remove simultaneous convergent pin	Removes the rightmost pin from the selected simultaneous divergent transition.
	Shift pin right	Increases the distance between the two rightmost pins of the currently selected transition, in order to let the SFC subnet linked to the pin on the left contain divergent branches.

Button	Command	Description
	Shift pin left	Decreases the distance between the two rightmost pins of the currently selected transition.
	New action code	Allows the user to create a new action to be associated with one of the steps. When you press this button, LogicLab asks you which language you want to use to implement the new action, then opens the corresponding editor.
	New transition code	Allows the user to write the code to be associated with one of the transitions. When you press this button, LogicLab asks you which language you want to use to implement the new transition, then opens the corresponding editor.

10.2.5 PROJECT TOOLBAR

Button	Command	Description
	Library manager	Opens the library manager.
	Compile	Asks you whether to save unsaved changes, then launches the LogicLab compiler.
	Recompile all	Asks you whether to save unsaved changes, then launches the LogicLab compiler to recompile the whole project.
	Connect to the target	LogicLab tries to establish a connection to the target.
	Code download	LogicLab checks if any changes have been applied since last compilation, and compiles the project if this is the case. Then, it sends the target the compiled code.
	New macro	Defines a new macro.
	Object browser	Opens the object browser, which lets you navigate between objects.
	PLC Obj properties	Shows properties and description of the object currently selected in the Workspace.
	Insert record	Adds a new row to the table in the currently active editor (if PLC editor, to the table of local variables; if parameters editor, to the table of parameters, etc.).
	Delete record	Deletes the variable in the selected row of the currently active table.
	Generate redistributable source module	Creates an RSM file of the project.

10.2.6 NETWORK TOOLBAR

Button	Command	Description
	Insert Top	Adds a blank network at the top of the active LD/FBD document.
	Insert Bottom	Adds a blank network at the bottom of the active LD/FBD document.
	Insert After	Adds a blank network after the selected network in the active LD/FBD document.
	Insert Before	Adds a blank network before the selected network in the active LD/FBD document.
	View grid	If checked, displays a dotted grid in the LD/FBD editor background.
	Auto connect	If checked, enables auto connection, that is automatic creation of a logical wire linking the pins of two blocks, when they are brought close.

10.2.7 DEBUG TOOLBAR

Button	Command	Description
	Debug mode	Switch on/off the *Debug* mode.
	Live debug mode	Switch on/off the *Live debug* mode.
	Set/Remove trigger	Sets/removes a trigger at the current source code line.
	Graphic trigger	Sets/removes a graphic trigger at the current source code line.
	Remove all triggers	Removes all triggers.
	Trigger list	Lists all triggers.
	Set breakpoints	Sets a breakpoint at the current source code line.
	Remove all breakpoints	Removes all breakpoints.
	Run	Restarts program execution after a breakpoint is hit.
	Breakpoint list	Lists all breakpoints.
	Change current instance	Changes the current function block instance (live debug mode).

11. LANGUAGE REFERENCE

All LogicLab languages are IEC 61131-3 standard-compliant.

- Common elements
- Instruction list (IL)
- Function block diagram (FBD)
- Ladder diagram (LD)
- Structured text (ST)
- Sequential Function Chart (SFC).

Moreover, LogicLab implements some extensions:

- Pointers
- Macros.

11.1 COMMON ELEMENTS

By common elements textual and graphic elements are means which are common to all the programmable controller programming languages specified by IEC 61131-3 standard.

Note: the definition and editing of the most part of the common elements (variables, structured elements, function blocks definitions etc.) are managed by LogicLab through specific editors, forms and tables.
LogicLab does not allow to edit directly the source code related to the above mentioned common elements.
The following paragraphs are meant as a language specification. To correctly manage common elements refer to the LogicLab user guide.

11.1.1 BASIC ELEMENTS

11.1.1.1 CHARACTER SET

Textual documents and textual elements of graphic languages are written by using the standard ASCII character set.

11.1.1.2 COMMENTS

User comments are delimited at the beginning and end by the special character combinations "(*" and "*)", respectively. Comments are permitted anywhere in the program, and they have no syntactic or semantic significance in any of the languages defined in this standard.

The use of nested comments, e.g., `(* (* NESTED *) *)`, is treated as an error.

11.1.2 ELEMENTARY DATA TYPES

A number of elementary (i.e. pre-defined) data types are made available by LogicLab, all compliant with IEC 61131-3 standard.

The elementary data types, keyword for each data type, number of bits per data element, and range of values for each elementary data type are described in the following table.

Keyword	Data type	Bits	Range
BOOL	Boolean	See note	0 to 1
SINT	Short integer	8	-128 to 127
USINT	Unsigned short integer	8	0 to 255
INT	Integer	16	-32768 to 32767

Keyword	Data type	Bits	Range
UINT	Unsigned integer	16	0 to 65536
DINT	Double integer	32	-2^{31} to $2^{31}-1$
UDINT	Unsigned long integer	32	0 to 2^{32}
BYTE	Bit string of length 8	8	—
WORD	Bit string of length 16	16	—
DWORD	Bit string of length 32	32	—
REAL	Real number	32	-3.40E+38 to +3.40E+38
STRING	String of characters	-	-

Note: the actual implementation of the BOOL data type depends on the processor of the target device, e.g. it is 1 bit long for devices that have a bit-addressable area.

11.1.3 DERIVED DATA TYPES

Derived data types can be declared using the TYPE...END_TYPE construct. These derived data types can then be used in variable declarations, in addition to the elementary data types.

Both single-element variables and elements of a multi-element variable, which are declared to be of derived data types, can be used anywhere that a variable of its parent type can be used.

11.1.3.1 TYPEDEFS

The purpose of typedefs is to assign alternative names to existing types. No difference between a typedef and its parent type exists, apart from the name.

Typedefs can be declared using the following syntax:

```
TYPE
<enumerated data type name> : <parent type name>;
END_TYPE
```

For example, consider the following declaration, mapping the name LONGWORD to the IEC 61131-3 standard type DWORD:

```
TYPE
longword : DWORD;
END_TYPE
```

11.1.3.2 ENUMERATED DATA TYPES

An enumerated data type declaration specifies that the value of any data element of that type can only be one of the values given in the associated list of identifiers. The enumeration list defines an ordered set of enumerated values, starting with the first identifier of the list, and ending with the last.

Enumerated data types can be declared using the following syntax:

```
TYPE
<enumerated data type name> : ( <enumeration list> );
END_TYPE
```

For example, consider the following declaration of two enumerated data types. Note that, when no explicit value is given to an identifier in the enumeration list, its value equals the value assigned to the previous identifier augmented by one.

```
TYPE
enum1: (
      val1, (* the value of val1 is 0 *)
      val2, (* the value of val2 is 1 *)
      val3  (* the value of val3 is 2 *)
);
enum2: (
      k := -11,
      i := 0,
      j,          (* the value of j is ( i + 1 ) = 1  *)
      l := 5
);
END_TYPE
```

Different enumerated data types may use the same identifiers for enumerated values. In order to be uniquely identified when used in a particular context, enumerated literals may be qualified by a prefix consisting of their associated data type name and the # sign.

11.1.3.3 SUBRANGES

A subrange declaration specifies that the value of any data element of that type is restricted between and including the specified upper and lower limits.

Subranges can be declared using the following syntax:

```
TYPE
<subrange name> : <parent type name> ( <lower limit>..<upper limit>
);
END_TYPE
```

For a concrete example consider the following declaration:

```
TYPE
int_0_to_100 : INT (0..100);
END_TYPE
```

11.1.3.4 STRUCTURES

A STRUCT declaration specifies that data elements of that type shall contain sub-elements of specified types which can be accessed by the specified names.

Structures can be declared using the following syntax:

```
TYPE
<structured type name> : STRUCT
      <declaration of stucture elements>
END_STRUCT;
END_TYPE
```

For example, consider the following declaration:

```
TYPE
structure1 : STRUCT
      elem1 : USINT;
      elem2 : USINT;
      elem3 : INT;
```

```
        elem3 : REAL;
    END_STRUCT;
    END_TYPE
```

11.1.4 LITERALS

11.1.4.1 NUMERIC LITERALS

External representation of data in the various programmable controller programming languages consists of numeric literals.

There are two classes of numeric literals: integer literals and real literals. A numeric literal is defined as a decimal number or a based number.

Decimal literals are represented in conventional decimal notation. Real literals are distinguished by the presence of a decimal point. An exponent indicates the integer power of ten by which the preceding number needs to be multiplied to obtain the represented value. Decimal literals and their exponents can contain a preceding sign (+ or -).

Integer literals can also be represented in base 2, 8 or 16. The base is in decimal notation. For base 16, an extended set of digits consisting of letters A through F is used, with the conventional significance of decimal 10 through 15, respectively. Based numbers do not contain any leading sign (+ or -).

Boolean data are represented by the keywords FALSE or TRUE.

Numerical literal features and examples are shown in the table below.

Feature description	Examples
Integer literals	-12 0 123 +986
Real literals	-12.0 0.0 0.4560
Real literals with exponents	-1.34E-12 or -1.34e-12 1.0E+6 or 1.0e+6 1.234E6 or 1.234e6
Base 2 literals	2#11111111 (256 decimal) 2#11100000 (240 decimal)
Base 8 literals	8#377 (256 decimal) 8#340 (240 decimal)
Base 16 literals	16#FF or 16#ff (256 decimal) 16#E0 or 16#e0 (240 decimal)
Boolean FALSE and TRUE	FALSE TRUE

11.1.4.2 CHARACTER STRING LITERALS

A character string literal is a sequence of zero or more characters prefixed and terminated by the single quote character (').

The three-character combination of the dollar sign ($) followed by two hexadecimal digits shall be interpreted as the hexadecimal representation of the eight-bit character code.

Example	Explanation
''	Empty string (length zero)
'A'	String of length one containing the single character A
' '	String of length one containing the *space* character
'$''	String of length one containing the *single quote* character

Example	Explanation
'"'	String of length one containing the *double quote* character
'RL'	String of length two containing CR and LF characters
'$0A'	String of length one containing the LF character

Two-character combinations beginning with the dollar sign shall be interpreted as shown in the following table when they occur in character strings.

Combination	Interpretation when printed
$$	Dollar sign
$'	Single quote
$L or $1	Line feed
$N or $n	Newline
$P or $p	Form feed (page)
$R or $r	Carriage return
$T or $t	Tab

11.1.5 VARIABLES

11.1.5.1 FOREWORD

Variables provide a means of identifying data objects whose contents may change, e.g., data associated with the inputs, outputs, or memory of the programmable controller. A variable must be declared to be one of the elementary types. Variables can be represented symbolically, or alternatively in a manner which directly represents the association of the data element with physical or logical locations in the programmable controller's input, output, or memory structure.

Each program organization unit (POU) (i.e., each program, function, or function block) contains at its beginning at least one declaration part, consisting of one or more structuring elements, which specify the types (and, if necessary, the physical or logical location) of the variables used in the organization unit. This declaration part has the textual form of one of the keywords VAR, VAR_INPUT, or VAR_OUTPUT as defined in the keywords section, followed in the case of VAR by zero or one occurrence of the qualifiers RETAIN, NON_RETAIN or the qualifier CONSTANT, and in the case of VAR_INPUT or VAR_OUTPUT by zero or one occurrence of the qualifier RETAIN or NON_RETAIN, followed by one or more declarations separated by semicolons and terminated by the keyword END_VAR. A declaration may also specify an initialization for the declared variable, when a programmable controller supports the declaration by the user of initial values for variables.

11.1.5.2 STRUCTURING ELEMENT

The declaration of a variable must be performed within the following program structuring element:

```
KEYWORD [RETAIN] [CONSTANT]
 Declaration 1
 Declaration 2
...
 Declaration N
END_VAR
```

11.1.5.3 KEYWORDS AND SCOPE

Keyword	Variable usage
VAR	Internal to organization unit.
VAR_INPUT	Externally supplied.
VAR_OUTPUT	Supplied by organization unit to external entities.
VAR_IN_OUT	Supplied by external entities, can be modified within organization unit.
VAR_EXTERNAL	Supplied by configuration via VAR_GLOBAL, can be modified within organization unit.
VAR_GLOBAL	Global variable declaration.

The scope (range of validity) of the declarations contained in structuring elements is local to the program organization unit (POU) in which the declaration part is contained. That is, the declared variables are accessible to other program organization units except by explicit argument passing via variables which have been declared as inputs or outputs of those units. The one exception to this rule is the case of variables which have been declared to be global. Such variables are only accessible to a program organization unit via a VAR_EXTERNAL declaration. The type of a variable declared in a VAR_EXTERNAL must agree with the type declared in the VAR_GLOBAL block.

There is an error if:

- any program organization unit attempts to modify the value of a variable that has been declared with the CONSTANT qualifier;
- a variable declared as VAR_GLOBAL CONSTANT in a configuration element or program organization unit (the “containing element”) is used in a VAR_EXTERNAL declaration (without the CONSTANT qualifier) of any element contained within the containing element.

11.1.5.4 QUALIFIERS

Qualifier	Description
CONST	The attribute CONST indicates that the variables within the structuring elements are constants, i.e. they have a constant value, which cannot be modified once the PLC project has been compiled.
RETAIN	The attribute RETAIN indicates that the variables within the structuring elements are retentive, i.e. they keep their value even after the target device is reset or switched off.

11.1.5.5 SINGLE-ELEMENT VARIABLES AND ARRAYS

A single-element variable represents a single data element of either one of the elementary types or one of the derived data types.

An array is a collection of data elements of the same data type; in order to access a single element of the array, a subscript (or index) enclosed in square brackets has to be used. Subscripts can be either integer literals or single-element variables.

To easily represent data matrices, arrays can be multi-dimensional; in this case, a composite subscript is required, one index per dimension, separated by commas. The maximum number of dimensions allowed in the definition of an array is three.

11.1.5.6 DECLARATION SYNTAX

Variables must be declared within structuring elements, using the following syntax:

```
VarName1 : Typename1 [ := InitialVal1 ];
VarName2 AT Location2 : Typename2 [ := InitialVal2 ];
VarName3 : ARRAY [ 0..N ] OF Typename3;
```

where:

Keyword	Description
VarNameX	Variable identifier, consisting of a string of alphanumeric characters, of length 1 or more. It is used for symbolic representation of variables.
TypenameX	Data type of the variable, selected from elementary data types.
InitialValX	The value the variable assumes after reset of the target.
LocationX	See the next paragraph.
N	Index of the last element, the array having length N + 1.

11.1.5.7 LOCATION

Variables can be represented symbolically, i.e. accessed through their identifier, or alternatively in a manner which directly represents the association of the data element with physical or logical locations in the programmable controller's input, output, or memory structure.

Direct representation of a single-element variable is provided by a special symbol formed by the concatenation of the percent sign "%" , a location prefix and a size prefix, and one or two unsigned integers, separated by periods (.).

```
%location.size.index.index
```

1) location

The location prefix may be one of the following:

Location prefix	Description
I	Input location
Q	Output location
M	Memory location

2) size

The size prefix may be one of the following:

Size prefix	Description
X	Single bit size
B	Byte (8 bits) size
W	Word (16 bits) size
D	Double word (32 bits) size

3) index.index

This sequence of unsigned integers, separated by dots, specifies the actual position of the variable in the area specified by the location prefix.

Example:

Direct representation	Description
%MW4.6	Word starting from the first byte of the 7th element of memory datablock 4.
%IX0.4	First bit of the first byte of the 5th element of input set 0.

Note that the absolute position depends on the size of the datablock elements, not on the size prefix. As a matter of fact, %MW4.6 and %MD4.6 begin from the same byte in memory, but the former points to an area which is 16 bits shorter than the latter.

For advanced users only: if the index consists of one integer only (no dots), then it loses any reference to datablocks, and it points directly to the byte in memory having the index value as its absolute address.

Direct representation	Description
%MW4.6	Word starting from the first byte of the 7th element of datablock 4 in memory.
%MW4	Word starting from byte 4 of memory.

Example

```
VAR [RETAIN] [CONSTANT]
    XQuote : DINT;    Enabling : BOOL := FALSE;
    TorqueCurrent AT %MW4.32 : INT;
    Counters : ARRAY [ 0 .. 9 ] OF UINT;
Limits: ARRAY [0..3, 0..9]
END_VAR
```

- Variable XQuote is 32 bits long, and it is automatically allocated by the LogicLab compiler.
- Variable Enabling is initialized to FALSE after target reset.
- Variable TorqueCurrent is allocated in the memory area of the target device, and it takes 16 bits starting from the first byte of the 33rd element of datablock 4.
- Variable Counters is an array of 10 independent variables of type unsigned integer.

11.1.5.8 DECLARING VARIABLES IN LOGICLAB

Whatever the PLC language you are using, LogicLab allows you to disregard the syntax above, as it supplies the Local variables editor, the Global variables editor, and the Parameters editor, which provide a friendly interface to declare all kinds of variables.

11.1.6 PROGRAM ORGANIZATION UNITS

Program organization units are functions, function blocks, and programs. These program organization units can be delivered by the manufacturer, or programmed by the user through the means defined in this part of the standard

Program organization units are not recursive; that is, the invocation of a program organization unit cannot cause the invocation of another program organization unit of the same type.

11.1.6.1 FUNCTIONS

Introduction

For the purposes of programmable controller programming languages, a function is defined as a program organization unit (POU) which, when executed, yields exactly one data element, which is considered to be the function result.

Functions contain no internal state information, i.e., invocation of a function with the same arguments (input variables VAR_INPUT and in-out variables VAR_IN_OUT) always yields the same values (output variables VAR_OUTPUT, in-out variables VAR_IN_OUT and function result).

Declaration syntax

The declaration of a function must be performed as follows:

```
FUNCTION FunctionName : RetDataType
VAR_INPUT
    declaration of input variables (see the relevant section)
END_VAR
VAR
    declaration of local variables (see the relevant section)
END_VAR
    Function body
END_FUNCTION
```

Keyword	Description
FunctionName	Name of the function being declared.
RetDataType	Data type of the value to be returned by the function.
Function body	Specifies the operations to be performed upon the input variables in order to assign values dependent on the function's semantics to a variable with the same name as the function, which represents the function result. It can be written in any of the languages supported by LogicLab.

Declaring functions in LogicLab

Whatever the PLC language you are using, LogicLab allows you to disregard the syntax above, as it supplies a friendly interface for using functions.

11.1.6.2 FUNCTION BLOCKS

Introduction

For the purposes of programmable controller programming languages, a function block is a program organization unit which, when executed, yields one or more values. Multiple, named instances (copies) of a function block can be created. Each instance has an associated identifier (the instance name), and a data structure containing its input, output and internal variables. All the values of the output variables and the necessary internal variables of this data structure persist from one execution of the function block to the next; therefore, invocation of a function block with the same arguments (input variables) does not always yield the same output values.

Only the input and output variables are accessible outside of an instance of a function block, i.e., the function block's internal variables are hidden from the user of the function block.

In order to execute its operations, a function block needs to be invoked by another POU.

Invocation depends on the specific language of the module calling the function block.

The scope of an instance of a function block is local to the program organization unit in which it is instantiated.

Declaration syntax

The declaration of a function must be performed as follows:

```
FUNCTION_BLOCK FunctionBlockName
 VAR_INPUT
     declaration of input variables (see the relevant section)
 END_VAR
 VAR_OUTPUT
     declaration of output variables
 END_VAR
 VAR_EXTERNAL
     declaration of external variables
 END_VAR
 VAR
     declaration of local variables
 END_VAR
    Function block body
END_FUNCTION_BLOCK
```

Keyword	Description
FunctionBlockName	Name of the function block being declared (note: name of the template, not of its instances).
VAR_EXTERNAL .. END_VAR	A function block can access global variables only if they are listed in a VAR_EXTERNAL structuring element. Variables passed to the FB via a VAR_EXTERNAL construct can be modified from within the FB.
Function block body	Specifies the operations to be performed upon the input variables in order to assign values to the output variables - dependent on the function block's semantics and on the value of the internal variables. It can be written in any of the languages supported by LogicLab.

Declaring functions in LogicLab

Whatever the PLC language you are using, LogicLab allows you to disregard the syntax above, as it supplies a friendly interface for using function blocks.

11.1.6.3 PROGRAMS

Introduction

A program is defined in IEC 61131-1 as a "logical assembly of all the programming language elements and constructs necessary for the intended signal processing required for the control of a machine or process by a programmable controller system.

Declaration syntax

The declaration of a program must be performed as follows:

```
PROGRAM < program name>
    Declaration of variables (see the relevant section)
    Program body
END_PROGRAM
```

Keyword	Description
Program Name	Name of the program being declared.
Program body	Specifies the operations to be performed to get the intended signal processing. It can be written in any of the languages supported by LogicLab.

Writing programs in LogicLab

Whatever the PLC language you are using, LogicLab allows you to disregard the syntax above, as it supplies a friendly interface for writing programs.

11.1.7 IEC 61131-3 STANDARD FUNCTIONS

This paragraph is a reference of all IEC 61131-3 standard functions available in LogicLab, along with a few others, which may be considered as LogicLab's exstensions to the standard.

These functions are common to the whole set of programming languages and can therefore be used in any Programmable Organization Unit (POU).

A function specified in this paragraph to be extensible (Ext.) is allowed to have a variable number of inputs.

Type conversion functions

According to the IEC 61131-3 standard, type conversion functions shall have the form *_TO_**, where "*" is the type of the input variable, and "**" the type of the output variable (for example, INT_TO_REAL). LogicLab provides a more convenient set of overloaded type conversion functions, relieving the developer to specify the input variable type.

TO_BOOL	
Description	Conversion to BOOL (boolean)
Number of operands	1
Input data type	Any numerical type
Output data type	BOOL

Examples	`out := TO_BOOL( 0 ); (* out = FALSE *)`
	`out := TO_BOOL( 1 ); (* out = TRUE *)`
	`out := TO_BOOL( 1000 ); (* out = TRUE *)`

TO_SINT	
Description	Conversion to SINT (8-bit signed integer)
Number of operands	1
Input data type	Any numerical type
Output data type	SINT
Examples	`out := TO_SINT( -1 ); (* out = -1 *)` `out := TO_SINT( 16#100 ); (* out = 0 *)`

TO_USINT	
Description	Conversion to USINT (8-bit unsigned integer)
Number of operands	1
Input data type	Any numerical type
Output data type	USINT
Examples	`out := TO_USINT( -1 ); (* out = 255 *)` `out := TO_USINT( 16#100 ); (* out = 0 *)`

TO_INT	
Description	Conversion to INT (16-bit signed integer)
Number of operands	1
Input data type	Any numerical type
Output data type	INT
Examples	`out := TO_INT( -1000.0 ); (* out = -1000 *)` `out := TO_INT( 16#8000 ); (* out = -32768 *)`

TO_UINT	
Description	Conversion to UINT (16-bit unsigned integer)
Number of operands	1
Input data type	Any numerical type
Output data type	UINT
Examples	`out := TO_UINT( 1000.0 ); (* out = 1000 *)` `out := TO_UINT( 16#8000 ); (* out = 32768 *)`

TO_DINT	
Description	Conversion to DINT (32-bit signed integer)
Number of operands	1
Input data type	Any numerical type
Output data type	DINT
Examples	`out := TO_DINT( 10.0 ); (* out = 10 *)` `out := TO_DINT( 16#FFFFFFFF ); (* out = -1 *)`

TO_UDINT	
Description	Conversion to UDINT (32-bit unsigned integer)
Number of operands	1
Input data type	Any numerical type
Output data type	UDINT
Examples	`out := TO_UDINT( 10.0 ); (* out = 10 *)` `out := TO_UDINT( 16#FFFFFFFF ); (* out = 4294967295 *)`

TO_BYTE	
Description	Conversion to BYTE (8-bit string)
Number of operands	1
Input data type	Any numerical type
Output data type	BYTE
Examples	`out := TO_BYTE( -1 ); (* out = 16#FF *)` `out := TO_BYTE( 16#100 ); (* out = 16#00 *)`

TO_WORD	
Description	Conversion to WORD (16-bit string)
Number of operands	1
Input data type	Any numerical type
Output data type	WORD
Examples	`out := TO_WORD( 1000.0 ); (* out = 16#03E8 *)` `out := TO_WORD( -32768 ); (* out = 16#8000 *)`

TO_DWORD	
Description	Conversion to DWORD (32-bit string)
Number of operands	1
Input data type	Any numerical type
Output data type	DWORD
Examples	`out := TO_DWORD( 10.0 ); (* out = 16#0000000A *)` `out := TO_DWORD( -1 ); (* out = 16#FFFFFFFF *)`

TO_REAL	
Description	Conversion to REAL (32-bit floating point)
Number of operands	1
Input data type	Any numerical type
Output data type	REAL
Examples	`out := TO_REAL( -1000 ); (* out = -1000.0 *)` `out := TO_REAL( 16#8000 ); (* out = -32768.0 *)`

TO_LREAL	
Description	Conversion to LREAL (64-bit floating point)
Number of operands	1
Input data type	Any numerical type
Output data type	LREAL
Examples	`out := TO_LREAL( -1000 ); (* out = -1000.0 *)` `out := TO_LREAL( 16#8000 ); (* out = -32768.0 *)`

Numerical functions

The availability of the following functions depends on the target device. Please refer to your hardware supplier for details.

ABS	
Description	Absolute value. Computes the absolute value of input #0
Number of operands	1
Input data type	Any numerical type
Output data type	Same as input

Examples	`OUT := ABS( -5 );(* OUT = 5 *)`
	`OUT := ABS( -1.618 );(* OUT = 1.618 *)`
	`OUT := ABS( 3.141592 );(* OUT = 3.141592 *)`

SQRT	
Description	Square root. Computes the square root of input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := SQRT( 4.0 ); (* OUT = 2.0 *)`

LN	
Description	Natural logarithm. Computes the logarithm with base e of input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := LN( 2.718281 ); (* OUT = 1.0 *)`

LOG	
Description	Common logarithm. Computes the logarithm with base 10 of input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := LOG( 100.0 );(* OUT = 2.0 *)`

EXP	
Description	Natural exponential. Computes the exponential function of input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := EXP( 1.0 ); (* OUT ~ 2.718281 *)`

SIN	
Description	Sine. Computes the sine function of input #0 expressed in radians
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := SIN( 0.0 ); (* OUT = 0.0 *)` `OUT := SIN( 2.5 * 3.141592 ); (* OUT ~ 1.0 *)`

COS	
Description	Cosine. Computes the cosine function of input #0 expressed in radians
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := COS( 0.0 ); (* OUT = 1.0 *)` `OUT := COS( -3.141592 ); (* OUT ~ -1.0 *)`

TAN	
Description	Tangent. Computes the tangent function of input #0 expressed in radians
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := TAN( 0.0 ); (* OUT = 0.0 *)` `OUT := TAN( 3.141592 / 4.0 ); (* OUT ~ 1.0 *)`

ASIN	
Description	Arc sine. Computes the principal arc sine of input #0; result is expressed in radians
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := ASIN( 0.0 ); (* OUT = 0.0 *)` `OUT := ASIN( 1.0 ); (* OUT = PI / 2 *)`

ACOS	
Description	Arc cosine. Computes the principal arc cosine of input #0; result is expressed in radians
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := ACOS( 1.0 ); (* OUT = 0.0 *)` `OUT := ACOS( -1.0 ); (* OUT = PI *)`

ATAN	
Description	Arc tangent. Computes the principal arc tangent of input #0; result is expressed in radians
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := ATAN( 0.0 ); (* OUT = 0.0 *)` `OUT := ATAN( 1.0 ); (* OUT = PI / 4 *)`

ADD	
Description	Arithmetic addition. Computes the sum of the two inputs.
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Inputs
Examples	`OUT := ADD( 20, 40 ); (* OUT = 60 *)`

MUL	
Description	Arithmetic multiplication. Multiplies the two inputs.
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Inputs
Examples	`OUT := MUL( 10, 10 ); (* OUT = 100 *)`

SUB	
Description	Arithmetic subtraction. Subtracts input #1 from input #0
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Inputs
Examples	`OUT := SUB( 10, 3 ); (* OUT = 7 *)`

DIV	
Description	Arithmetic division. Divides input #0 by input #1
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Inputs
Examples	`OUT := DIV( 20, 2 ); (* OUT = 10 *)`

MOD	
Description	Module. Computes input #0 module input #1
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Inputs
Examples	`OUT := MOD( 10, 3 ); (* OUT = 1 *)`

POW	
Description	Exponentiation. Raises Base to the power Expo
Number of operands	2
Input data type	LREAL where available, REAL otherwise; LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := POW( 2.0, 3.0 ); (* OUT = 8.0 *)` `OUT := POW( -1.0, 5.0 ); (* OUT = -1.0 *)`

ATAN2*	
Description	Arc tangent (with 2 parameters). Computes the principal arc tangent of Y/X; result is expressed in radians
Number of operands	2
Input data type	LREAL where available, REAL otherwise; LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise

Examples	`OUT := ATAN2( 0.0, 1.0 ); (* OUT = 0.0 *)`
	`OUT := ATAN2( 1.0, 1.0 ); (* OUT = PI / 4 *)`
	`OUT := ATAN2( -1.0, -1.0 ); (* OUT = ( -3/4 ) * PI *)`
	`OUT := ATAN2( 1.0, 0.0 ); (* OUT = PI / 2 *)`

SINH*	
Description	Hyperbolic sine. Computes the hyperbolic sine function of input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := SINH( 0.0 ); (* OUT = 0.0 *)`

COSH*	
Description	Hyperbolic cosine. Computes the hyperbolic cosine function of input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := COSH( 0.0 ); (* OUT = 1.0 *)`

TANH*	
Description	Hyperbolic tangent. Computes the hyperbolic tangent function of input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := TANH( 0.0 ); (* OUT = 0.0 *)`

CEIL*	
Description	Rounding up to integer. Returns the smallest integer that is greater than or equal to input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := CEIL( 1.95 ); (* OUT = 2.0 *)` `OUT := CEIL( -1.27 ); (* OUT = -1.0 *)`

FLOOR*	
Description	Rounding down to integer. Returns the largest integer that is less than or equal to input #0
Number of operands	1
Input data type	LREAL where available, REAL otherwise
Output data type	LREAL where available, REAL otherwise
Examples	`OUT := FLOOR( 1.95 ); (* OUT = 1.0 *)` `OUT := FLOOR( -1.27 ); (* OUT = -2.0 *)`

*: function provided as extension to the IEC 61131-3 standard.

Bit string functions

SHL	
Description	Input#0 left-shifted of Input #1 bits, zero filled on the right.
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Input #0
Examples	`OUT := SHL( IN := 16#1000CAFE, 16 );` `(* OUT = 16#CAFE0000 *)`

SHR	
Description	Input #0 right-shifted of Input #1 bits, zero filled on the left.
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Input #0
Examples	`OUT := SHR( IN := 16#1000CAFE, 24 );` `(* OUT = 16#00000010 *)`

ROL	
Description	Input #0 left-shifted of Input #1 bits, circular.
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Input #0
Examples	`OUT := ROL( IN := 16#1000CAFE, 4 );` `(* OUT = 16#000CAFE1 *)`

ROR	
Description	Input #0 right-shifted of Input #1 bits, circular.
Number of operands	2
Input data type	Any numerical type, Any numerical type
Output data type	Same as Input #0
Examples	`OUT := ROR( IN := 16#1000CAFE, 16 );` `(* OUT = 16#CAFE1000 *)`

AND	
Description	Logical AND if both Input #0 and Input #1 are BOOL, otherwise bitwise AND.
Number of operands	2
Input data type	Any but STRING, Any but STRING
Output data type	Same as Inputs
Examples	`OUT := TRUE AND FALSE;  (* OUT = FALSE *)` `OUT := 16#1234 AND 16#5678;  (* OUT = 16#1230 *)`

OR	
Description	Logical OR if both Input #0 and Input #1 are BOOL, otherwise bitwise OR.
Number of operands	2
Input data type	Any but STRING, Any but STRING
Output data type	Same as Inputs
Examples	`OUT := TRUE OR FALSE; (* OUT = FALSE *)` `OUT := 16#1234 OR 16#5678;(* OUT = 16#567C *)`

XOR	
Description	Logical XOR if both Input #0 and Input #1 are BOOL, otherwise bitwise XOR.
Number of operands	2
Input data type	Any but STRING, Any but STRING
Output data type	Same as Inputs
Examples	`OUT := TRUE OR FALSE; (* OUT = TRUE *)` `OUT := 16#1234 OR 16#5678; (* OUT = 16#444C *)`

NOT	
Description	Logical NOT if Input is BOOL, otherwise bitwise NOT.
Number of operands	1
Input data type	Any but STRING
Output data type	Same as Inputs
Examples	`OUT := NOT FALSE; (* OUT = TRUE *)` `OUT := NOT 16#1234;(* OUT = 16#EDCB *)`

Selection functions

SEL	
Description	Binary selection
Number of operands	3
Input data type	BOOL, Any, Any
Output data type	Same as selected Input
Examples	`OUT := SEL( G := FALSE, IN0 := X, IN1 := 5 );` `(* OUT = X *)`

MAX	
Description	Maximum value selection
Number of operands	2, extensible
Input data type	Any numerical type, Any numerical type, .., Any numerical type
Output data type	Same as max Input
Examples	`OUT := MAX( -8, 120, -1000 ); (* OUT = 120 *)`

MIN	
Description	Minimum value selection
Number of operands	2, extensible
Input data type	Any numerical type, Any numerical type, .., Any numerical type
Output data type	Same as min Input
Examples	`OUT := MIN( -8, 120, -1000 ); (* OUT = -1000 *)`

LIMIT	
Description	Limits Input #0 to be equal or more than Input#1, and equal or less than Input #2.
Number of operands	3
Input data type	Any numerical type, Any numerical type, Any numerical type
Output data type	Same as Inputs

Examples	`OUT := LIMIT( IN := 4, MN := 0, MX := 5 ); (* OUT = 4 *)`
	`OUT := LIMIT( IN := 88, MN := 0, MX := 5 );(* OUT = 5 *)`
	`OUT := LIMIT( IN := -1, MN := 0, MX := 5 );(* OUT = 0 *)`

MUX	
Description	Multiplexer. Selects one of N inputs depending on input K
Number of operands	3, extensible
Input data type	Any numerical type, Any numerical type, ..., Any numerical type
Output data type	Same as selected Input
Examples	`OUT := MUX( 0, A, B, C ); (* OUT = A *)`

Comparison functions

Comparison functions can be also used to compare strings if this feature is supported by target device.

GT	
Description	Greater than. Returns TRUE if Input #0 > Input #1, otherwise FALSE.
Number of operands	2
Input data type	Any but BOOL, Any but BOOL
Output data type	BOOL
Examples	`OUT := GT( 0, 20 ); (* OUT = FALSE *)` `OUT := GT( 'pippo', 'pluto' ); (* OUT = TRUE *)`

GE	
Description	Greater than or equal to. Returns TRUE if Input #0 >= Input #1, otherwise FALSE.
Number of operands	2
Input data type	Any but BOOL, Any but BOOL
Output data type	BOOL
Examples	`OUT := GE( 20, 20 ); (* OUT = TRUE *)` `OUT := GE( 'pippo', 'pluto' ); (* OUT = FALSE *)`

EQ	
Description	Equal to. Returns TRUE if Input #0 = Input #1, otherwise FALSE.
Number of operands	2
Input data type	Any, Any
Output data type	BOOL
Examples	`OUT := EQ( TRUE, FALSE );  (* OUT = FALSE *)` `OUT := EQ( 'pippo', 'pluto' ); (* OUT = FALSE *)`

LT	
Description	Less than. Returns TRUE if Input #0 < Input #1, otherwise FALSE.
Number of operands	2
Input data type	Any but BOOL, Any but BOOL
Output data type	BOOL
Examples	`OUT := LT( 0, 20 ); (* OUT = TRUE *)` `OUT := LT( 'pipp', 'pluto' ); (* OUT = TRUE *)`

LE	
Description	Less than or equal to. Returns TRUE if Input #0 <= Input #1, otherwise FALSE.
Number of operands	2
Input data type	Any but BOOL, Any but BOOL
Output data type	BOOL
Examples	`OUT := LE( 20, 20 ); (* OUT = TRUE *)` `OUT := LE( 'pipp', 'pluto' ); (* OUT = TRUE *)`

NE	
Description	Not equal to. Returns TRUE if Input #0 != Input #1, otherwise FALSE.
Number of operands	2
Input data type	Any, Any
Output data type	BOOL
Examples	`OUT := NE( TRUE, FALSE ); (* OUT = TRUE *)` `OUT := NE( 'pipp', 'pluto' ); (* OUT = TRUE *)`

String functions

The availability of the following functions depends on the target device. Please refer to your hardware supplier for details.

CONCAT	
Description	Character string concatenation
Number of operands	2
Input data type	STRING, STRING
Output data type	STRING
Examples	`OUT := CONCAT( 'AB', 'CD' ); (* OUT = 'ABCD' *)`

DELETE	
Description	Delete L characters of IN, beginning at the P-th character position
Number of operands	3
Input data type	STRING, UINT, UINT
Output data type	STRING
Examples	`OUT := DELETE( IN := 'ABXYC', L := 2, P := 3 );` `(* OUT = 'ABC' *)`

FIND	
Description	Find the character position of the beginning of the first occurrence of IN2 in IN1. If no occurrence of IN2 is found, then OUT := 0.
Number of operands	2
Input data type	STRING, STRING
Output data type	UINT
Examples	`OUT := FIND( IN1 := 'ABCBC', IN2 := 'BC' ); (* OUT = 2 *)`

INSERT	
Description	Insert IN2 into IN1 after the P-th character position
Number of operands	3
Input data type	STRING, STRING, UINT
Output data type	STRING
Examples	`OUT := INSERT( IN1 := 'ABC', IN2 := 'XY', P := 2 );` `(* OUT = 'ABXYC' *)`

LEFT	
Description	Leftmost L characters of IN
Number of operands	2
Input data type	STRING, UINT
Output data type	STRING
Examples	`OUT := LEFT( IN := 'ASTR', L := 3 ); (* OUT = 'AST' *)`

LEN	
Description	String length function
Number of operands	1
Input data type	STRING
Output data type	UINT
Examples	`OUT := LEN( 'ASTRING' ); (* OUT = 7 *)`

MID	
Description	L characters of IN, beginning at the P-th
Number of operands	3
Input data type	STRING, UINT, UINT
Output data type	STRING
Examples	`OUT := MID( IN := 'ASTR', L := 2, P := 2 );` `(* OUT = 'ST' *)`

REPLACE	
Description	Replace L characters of IN1 by IN2, starting at the P-th character position
Number of operands	4
Input data type	STRING, STRING, UINT, UINT
Output data type	STRING
Examples	`OUT := REPLACE( IN1 := 'ABCDE', IN2 := 'X', L := 2, P := 3 ); (* OUT = 'ABXE' *)`

RIGHT	
Description	Rightmost L characters of IN
Number of operands	2
Input data type	STRING, UINT
Output data type	STRING
Examples	`OUT := RIGHT( IN := 'ASTR', L := 3 ); (* OUT = 'STR' *)`

11.2 INSTRUCTION LIST (IL)

This section defines the semantics of the IL (Instruction List) language.

11.2.1 SYNTAX AND SEMANTICS

11.2.1.1 SYNTAX OF IL INSTRUCTIONS

IL code is composed of a sequence of instructions. Each instruction begins on a new line and contains an operator with optional modifiers, and, if necessary for the particular operation, one or more operands separated by commas. Operands can be any of the data representations for literals and for variables.

The instruction can be preceded by an identifying label followed by a colon (:). Empty lines can be inserted between instructions.

Example

Let us parse a small piece of code:

```
START:
    LD %IX1 (* Push button *)
    ANDN %MX5.4 (* Not inhibited *)
    ST %QX2 (* Fan out *)
```

The elements making up each instruction are classified as follows:

Label	Operator [+ modifier]	Operand	Comment
START:	LD	%IX1	(* Push button *)
	ANDN	%MX5.4	(* Not inhibited *)
	ST	%QX2	(* Fan out *)

Semantics of IL instructions

- Accumulator

  By accumulator a register is meant containing the value of the currently evaluated result.

- Operators

  Unless otherwise specified, the semantics of the operators is

  ```
  accumulator := accumulator OP operand
  ```

  That is, the value of the accumulator is replaced by the result yielded by operation OP applied to the current value of the accumulator itself, with respect to the operand. For instance, the instruction "`AND %IX1`" is interpreted as

  ```
  accumulator := accumulator AND %IX1
  ```

  and the instruction "`GT %IW10`" will have the Boolean result `TRUE` if the current value of the accumulator is greater than the value of input word 10, and the Boolean result `FALSE` otherwise:

  ```
  accumulator := accumulator GT %IW10
  ```

- Modifiers

  The modifier "`N`" indicates bitwise negation of the operand.

  The left parenthesis modifier "(" indicates that evaluation of the operator must be deferred until a right parenthesis operator ")" is encountered. The form of a parenthesized sequence of instructions is shown below, referred to the instruction

  ```
  accumulator := accumulator AND (%MX1.3 OR %MX1.4)
  ```

  The modifier "`C`" indicates that the associated instruction can be performed only if the value of the currently evaluated result is Boolean 1 (or Boolean 0 if the operator is combined with the "`N`" modifier).

11.2.2 STANDARD OPERATORS

Standard operators with their allowed modifiers and operands are as listed below.

Operator	Modifiers	Supported operand types: Acc_type, Op_type	Semantics
LD	N	Any, Any	Sets the accumulator equal to operand.
ST	N	Any, Any	Stores the accumulator into operand location.

Operator	Modifiers	Supported operand types: Acc_type, Op_type	Semantics
S		BOOL, BOOL	Sets operand to TRUE if accumulator is TRUE.
R		BOOL, BOOL	Sets operand to FALSE if accumulator is TRUE.
AND	N, (	Any but REAL, Any but REAL	Logical or bitwise AND
OR	N, (	Any but REAL, Any but REAL	Logical or bitwise OR
XOR	N, (	Any but REAL, Any but REAL	Logical or bitwise XOR
NOT		Any but REAL	Logical or bitwise NOT
ADD	(	Any but BOOL	Addition
SUB	(	Any but BOOL	Subtraction
MUL	(	Any but BOOL	Multiplication
DIV	(	Any but BOOL	Division
MOD	(	Any but BOOL	Modulo-division
GT	(	Any but BOOL	Comparison:
GE	(	Any but BOOL	Comparison: =
EQ	(	Any but BOOL	Comparison: =
NE	(	Any but BOOL	Comparison:
LE	(	Any but BOOL	Comparison:
LT	(	Any but BOOL	Comparison:
JMP	C, N	Label	Jumps to label
CAL	C, N	FB instance name	Calls function block
RET	C, N		Returns from called program, function, or function block.
)			Evaluates deferred operation.

11.2.3 CALLING FUNCTIONS AND FUNCTION BLOCKS

11.2.3.1 CALLING FUNCTIONS

Functions (as defined in the relevant section) are invoked by placing the function name in the operator field. This invocation takes the following form:

```
LD 1
MUX 5, var0, -6.5, 3.14
ST vRES
```

Note that the first argument is not contained in the input list, but the accumulator is used as the first argument of the function. Additional arguments (starting with the 2nd), if required, are given in the operand field, separated by commas, in the order of their declaration. For example, operator MUX in the table above takes 5 operands, the first of which is loaded into the accumulator, whereas the remaining 4 arguments are orderly reported after the function name.

The following rules apply to function invocation.

1) Assignments to VAR_INPUT arguments may be empty, constants, or variables.
2) Execution of a function ends upon reaching a RET instruction or the physical end of the function. When this happens, the output variable of the function is copied into the accumulator.

Calling Function Blocks

Function blocks (as defined in the relevant section) can be invoked conditionally and unconditionally via the CAL operator. This invocation takes the following form:

```
LD A
ADD 5
ST INST5.IN1
LD 3.141592
ST INST5.IN2
CAL INST5
LD INST5.OUT1
ST vRES
LD INST5.OUT2
ST vVALID
```

This method of invocation is equivalent to a CAL with an argument list, which contains only one variable with the name of the FB instance.

Input arguments are passed to / output arguments are read from the FB instance through ST / LD operations performed on operands taking the following form:

FBInstanceName.IO_var

where

Keyword	Description
FBInstanceName	Name of the instance to be invoked.
IO_var	Input or output variable to be written / read.

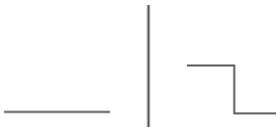
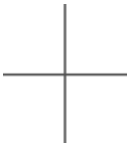
11.3 FUNCTION BLOCK DIAGRAM (FBD)

This section defines the semantics of the FBD (Function Block Diagram) language.

11.3.1 REPRESENTATION OF LINES AND BLOCKS

The graphic language elements are drawn using graphic or semi graphic elements, as shown in the table below.

No storage of data or association with data elements can be associated with the use of connectors; hence, to avoid ambiguity, connectors cannot be given any identifier.

Feature	Example
Lines	
Line crossing with connection	
Blocks with connecting lines and unconnected pins	

11.3.2 DIRECTION OF FLOW IN NETWORKS

A network is defined as a maximal set of interconnected graphic elements. A network label delimited on the right by a colon (:) can be associated with each network or group of networks. The scope of a network and its label is local to the program organization unit (POU) where the network is located.

Graphic languages are used to represent the flow of a conceptual quantity through one or more networks representing a control plan. Namely, in the case of function block diagrams (FBD), the "Signal flow" is typically used, analogous to the flow of signals between elements of a signal processing system. Signal flow in the FBD language is from the output (right-hand) side of a function or function block to the input (left-hand) side of the function or function block(s) so connected.

11.3.3 EVALUATION OF NETWORKS

11.3.3.1 ORDER OF EVALUATION OF NETWORKS

The order in which networks and their elements are evaluated is not necessarily the same as the order in which they are labeled or displayed. When the body of a program organization unit (POU) consists of one or more networks, the results of network evaluation within said body are functionally equivalent to the observance of the following rules:

1) No element of a network is evaluated until the states of all of its inputs have been evaluated.
2) The evaluation of a network element is not complete until the states of all of its outputs have been evaluated.
3) As stated when describing the FBD editor, a network number is automatically assigned to every network. Within a program organization unit (POU), networks are evaluated according to the sequence of their number: network `N` is evaluated before network `N+1`, unless otherwise specified by means of the execution control elements.

11.3.3.2 COMBINATION OF ELEMENTS

Elements of the FBD language must be interconnected by signal flow lines.

Outputs of blocks shall not be connected together. In particular, the "`wired-OR`" construct of the LD language is not allowed, as an explicit Boolean "`OR`" block is required.

Feedback

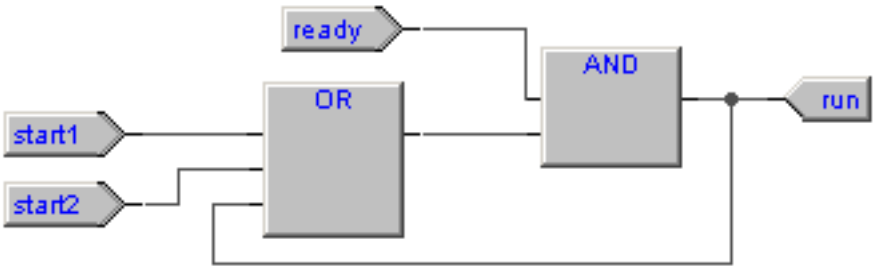
A feedback path is said to exist in a network when the output of a function or function block is used as the input to a function or function block which precedes it in the network; the associated variable is called a feedback variable.

Feedback paths can be utilized subject to the following rules:

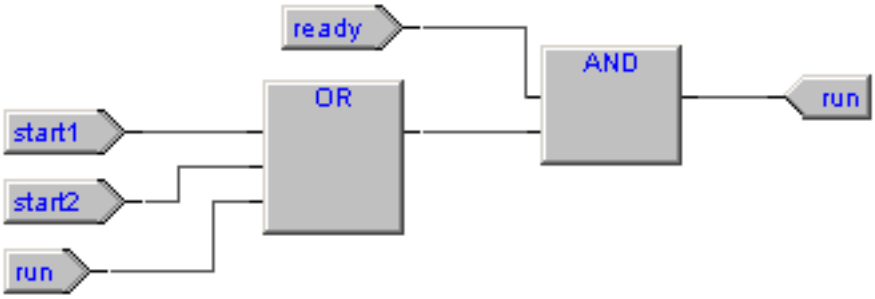
1) Feedback variables must be initialized, and the initial value is used during the first evaluation of the network. Look the Global variables editor, the Local variables editor, or the Parameters editor to know how to initialize the respective item.
2) Once the element with a feedback variable as output has been evaluated, the new value of the feedback variable is used until the next evaluation of the element.

For instance, the Boolean variable RUN is the feedback variable in the example shown below.

Explicit loop



Implicit loop



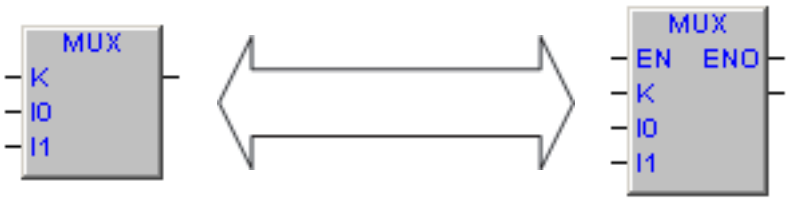
11.3.4 EXECUTION CONTROL ELEMENTS

11.3.4.1 EN/ENO SIGNALS

Additional Boolean EN (Enable) input and ENO (Enable Out) characterize LogicLab blocks, according to the declarations

EN	ENO
VAR_INPUT	VAR_OUTPUT
EN: BOOL := 1;	ENO: BOOL;
END_VAR	END_VAR

See the Modifying properties of blocks section to know how to add these pins to a block.



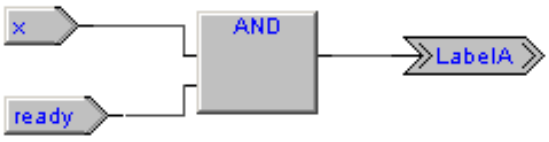
When these variables are used, the execution of the operations defined by the block are controlled according to the following rules:

1) If the value of EN is FALSE when the block is invoked, the operations defined by the function body are not executed and the value of ENO is reset to FALSE by the programmable controller system.
2) Otherwise, the value of ENO is set to TRUE by the programmable controller system, and the operations defined by the block body are executed.

11.3.4.2 JUMPS

Jumps are represented by a Boolean signal line terminated in a double arrowhead. The signal line for a jump condition originates at a Boolean variable, or at a Boolean output of a function or function block. A transfer of program control to the designated network label occurs when the Boolean value of the signal line is TRUE; thus, the unconditional jump is a special case of the conditional jump.

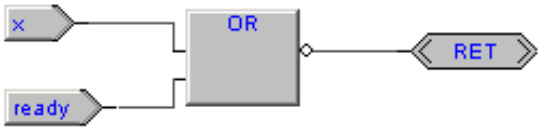
The target of a jump is a network label within the program organization unit within which the jump occurs.

Symbol / Example	Explanation
	Unconditional Jump
	Conditional Jump
	Example: Jump Condition Network

11.3.4.3 CONDITIONAL RETURNS

- Conditional returns from functions and function blocks are implemented using a RETURN construction as shown in the table below. Program execution is transferred back to the invoking entity when the Boolean input is TRUE, and continues in the normal fashion when the Boolean input is FALSE.

- Unconditional returns are provided by the physical end of the function or function block.

Symbol / Example	Explanation
	Conditional Return
	Example: Return Condition Network

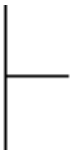
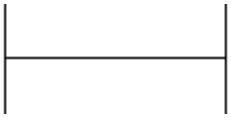
11.4 LADDER DIAGRAM (LD)

This section defines the semantics of the LD (Ladder Diagram) language.

11.4.1 POWER RAILS

The LD network is delimited on the left side by a vertical line known as the left power rail, and on the right side by a vertical line known as the right power rail. The right power rail may be explicit in the LogicLab implementation and it is always shown.

The two power rails are always connected with an horizontal line named signal link. All LD elements should be placed and connected to the signal link.

Description	Symbol
Left power rail (with attached horizontal link)	
Right power rail (with attached horizontal link)	
Power rails connected by the signal link	

11.4.2 LINK ELEMENTS AND STATES

Link elements may be horizontal or vertical. The state of the link elements shall be denoted “ON” or “OFF”, corresponding to the literal Boolean values 1 or 0, respectively. The term link state shall be synonymous with the term power flow.

The following properties apply to the link elements:

- The state of the left rail shall be considered ON at all times. No state is defined for the right rail.

- A horizontal link element is indicated by a horizontal line. A horizontal link element transmits the state of the element on its immediate left to the element on its immediate right.
- The vertical link element consists of a vertical line intersecting with one or more horizontal link elements on each side. The state of the vertical link represents the inclusive OR of the ON states of the horizontal links on its left side, that is, the state of the vertical link is:

  OFF if the states of all the attached horizontal links to its left are OFF;

  ON if the state of one or more of the attached horizontal links to its left is ON.
- The state of the vertical link is copied to all of the attached horizontal links on its right.
- The state of the vertical link is not copied to any of the attached horizontal links on its left.

Description	Symbol
Vertical link with attached horizontal links	

11.4.3 CONTACTS

A contact is an element which imparts a state to the horizontal link on its right side which is equal to the Boolean AND of the state of the horizontal link at its left side with an appropriate function of an associated Boolean input, output, or memory variable.

A contact does not modify the value of the associated Boolean variable. Standard contact symbols are given in the following table.

Name	Description	Symbol
Normally open contact	The state of the left link is copied to the right link if the state of the associated Boolean variable is ON. Otherwise, the state of the right link is OFF.	
Normally closed contact	The state of the left link is copied to the right link if the state of the associated Boolean variable is OFF. Otherwise, the state of the right link is OFF.	
Positive transition-sensing contact	The state of the right link is ON from one evaluation of this element to the next when a transition of the associated variable from OFF to ON is sensed at the same time that the state of the left link is ON. The state of the right link shall be OFF at all other times.	

Name	Description	Symbol
Negative transition-sensing contact	The state of the right link is ON from one evaluation of this element to the next when a transition of the associated variable from ON to OFF is sensed at the same time that the state of the left link is ON. The state of the right link shall be OFF at all other times.	

11.4.4 COILS

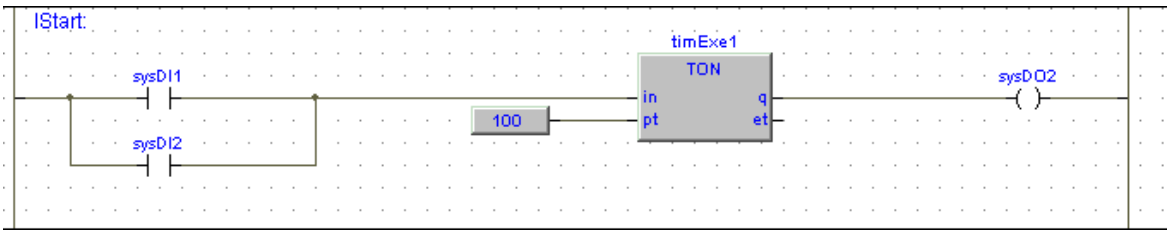
A coil copies the state of the link on its left side to the link on its right side without modification, and stores an appropriate function of the state or transition of the left link into the associated Boolean variable.

Standard coil symbols are shown in the following table.

Name	Description	Symbol
Coil	The state of the left link is copied to the associated Boolean variable.	
Negated coil	The inverse of the state of the left link is copied to the associated Boolean variable, that is, if the state of the left link is OFF, then the state of the associated variable is ON, and vice versa.	
SET (latch) coil	The associated Boolean variable is set to the ON state when the left link is in the ON state, and remains set until reset by a RESET coil.	
RESET (unlatch) coil	The associated Boolean variable is reset to the OFF state when the left link is in the ON state, and remains reset until set by a SET coil.	
Positive transition-sensing coil	The state of the associated Boolean variable is ON from one evaluation of this element to the next when a transition of the left link from OFF to ON is sensed.	
Negative transition-sensing coil	The state of the associated Boolean variable is ON from one evaluation of this element to the next when a transition of the left link from ON to OFF is sensed.	

11.4.5 OPERATORS, FUNCTIONS AND FUNCTION BLOCKS

The representation of functions and function blocks in the LD language is similar to the one used for FBD. At least one Boolean input and one Boolean output shall be shown on each block to allow for power flow through the block as shown in the following figure.



11.5 STRUCTURED TEXT (ST)

This section defines the semantics of the ST (Structured Text) language.

11.5.1 EXPRESSIONS

An expression is a construct which, when evaluated, yields a value corresponding to one of the data types listed in the elementary data types table. LogicLab does not set any constraint on the maximum length of expressions.

Expressions are composed of operators and operands.

11.5.1.1 OPERANDS

An operand can be a literal, a variable, a function invocation, or another expression.

11.5.1.2 OPERATORS

Open the table of operators to see the list of all the operators supported by ST. The evaluation of an expression consists of applying the operators to the operands in a sequence defined by the operator precedence rules.

11.5.1.3 OPERATOR PRECEDENCE RULES

Operators have different levels of precedence, as specified in the table of operators. The operator with highest precedence in an expression is applied first, followed by the operator of next lower precedence, etc., until evaluation is complete. Operators of equal precedence are applied as written in the expression from left to right.

For example if A, B, C, and D are of type INT with values 1, 2, 3, and 4, respectively, then:

```
A+B-C*ABS(D)
```

yields -9, and:

```
(A+B-C)*ABS(D)
```

yields 0.

When an operator has two operands, the leftmost operand is evaluated first. For example, in the expression

```
SIN(A)*COS(B)
```

the expression `SIN(A)` is evaluated first, followed by `COS(B)`, followed by evaluation of the product.

Functions are invoked as elements of expressions consisting of the function name followed by a parenthesized list of arguments, as defined in the relevant section.

11.5.1.4 OPERATORS OF THE ST LANGUAGE

Operation	Symbol	Precedence
Parenthesization	(<expression>)	HIGHEST
Function evaluation	<fname>(<arglist>)	.
Negation Complement	- NOT	.
Exponentiation	**	.
Multiply Divide Modulo	* / MOD	.
Add Subtract	+ -	.
Comparison	<, >, <=, >=	.
Equality Inequality	= <>	.
Boolean AND	AND	.
Boolean Exclusive OR	XOR	.
Boolean OR	OR	LOWEST

11.5.2 STATEMENTS IN ST

All statements comply with the following rules:

- they are terminated by semicolons;
- unlike IL, a carriage return or new line character is treated the same as a space character;
- LogicLab does not set any constraint on the maximum length of statements.

ST statements can be divided into classes, according to their semantics.

11.5.2.1 ASSIGNMENTS

Semantics

The assignment statement replaces the current value of a single or multi-element variable by the result of evaluating an expression.

The assignment statement is also used to assign the value to be returned by a function, by placing the function name to the left of an assignment operator in the body of the function declaration. The value returned by the function is the result of the most recent evaluation of such an assignment.

Syntax

An assignment statement consists of a variable reference on the left-hand side, followed by the assignment operator ":=", followed by the expression to be evaluated. For instance, the statement

```
A := B ;
```

would be used to replace the single data value of variable A by the current value of variable B if both were of type INT.

Examples

```
  a := b ;
```

assignment

```
  pCV := pCV + 1 ;
```

assignment

```
  c := SIN( x );
```

assignment with function invocation

```
  FUNCTION SIMPLE_FUN : REAL
  variables declaration
  ...
  function body
  ...
  SIMPLE_FUN := a * b - c ;
  END_FUNCTION
```

assigning the output value to a function

11.5.2.2 FUNCTION AND FUNCTION BLOCK STATEMENTS

Semantics

- Functions are invoked as elements of expressions consisting of the function name followed by a parenthesized list of arguments. Each argument can be a literal, a variable, or an arbitrarily complex expression.
- Function blocks are invoked by a statement consisting of the name of the function block instance followed by a parenthesized list of arguments. Both invocation with formal argument list and with assignment of arguments are supported.
- RETURN: function and function block control statements consist of the mechanisms for invoking function blocks and for returning control to the invoking entity before the physical end of a function or function block. The RETURN statement provides early exit from a function or a function block (e.g., as the result of the evaluation of an IF statement).

Syntax

1) Function:

```
dst_var := function_name( arg1, arg2 , ... , argN );
```

2) Function block with formal argument list:

```
instance_name(    var_in1 := arg1 ,
                  var_in2 := arg2 ,
                  ... ,
                  var_inN := argN );
```

3) Function block with assignment of arguments:

```
instance_name.var_in1 := arg1;
...
instance_name.var_inN := argN;
instance_name();
```

4) Function and function block control statement:

```
RETURN;
```

Examples

```
CMD_TMR( IN := %IX5,
 PT:= 300 ) ;
```

FB invocation with formal argument list:

```
IN := %IX5 ;
PT:= 300 ;
CMD_TMR() ;
```

FB invocation with assignment of arguments:

```
a := CMD_TMR.Q;
```

FB output usage:

```
RETURN ;
```

early exit from function or function block.

11.5.2.3 SELECTION STATEMENTS

Semantics

Selection statements include the IF and CASE statements. A selection statement selects one (or a group) of its component statements for execution based on a specified condition.

- IF: the IF statement specifies that a group of statements is to be executed only if the associated Boolean expression evaluates to the value TRUE. If the condition is false, then either no statement is to be executed, or the statement group following the ELSE keyword (or the ELSIF keyword if its associated Boolean condition is true) is executed.
- CASE: the CASE statement consists of an expression which evaluates to a variable of type DINT (the “selector”), and a list of statement groups, each group being labeled by one or more integer or ranges of integer values, as applicable. It specifies that the first group of statements, one of whose ranges contains the computed value of the selector, is to be executed. If the value of the selector does not occur in a range of any case, the statement sequence following the keyword ELSE (if it occurs in the CASE statement) is executed. Otherwise, none of the statement sequences is executed.

LogicLab does not set any constraint on the maximum allowed number of selections in CASE statements.

Syntax

Note that square brackets include optional code, while braces include repeatable portions of code.

1) IF:

```
IF expression1 THEN
stat_list
[ { ELSIF expression2 THEN
stat_list } ]
ELSE
stat_list
END_IF ;
```

2) CASE:

```
CASE expression1 OF
intv [ {, intv } ] :
stat_list
{ intv [ {, intv } ] :
stat_list }
[ ELSE
stat_list ]
```

```
    END_CASE ;
    intv being either a constant or an interval: a or a..b
```

Examples

IF statement:

```
  IF d 0.0 THEN
  nRoots := 0 ;
  ELSIF d = 0.0 THEN
  nRoots := 1 ;
  x1 := -b / (2.0 * a) ;
  ELSE
  nRoots := 2 ;
  x1 := (-b + SQRT(d)) / (2.0 * a) ;
  x2 := (-b - SQRT(d)) / (2.0 * a) ;
  END_IF ;
```

CASE statement:

```
  CASE tw OF
  1, 5:
  display := oven_temp ;
  2:
  display := motor_speed ;
  3:
  display := gross_tare;
  4, 6..10:
  display := status(tw - 4) ;
  ELSE
   display := 0;
   tw_error := 1;
  END_CASE ;
```

11.5.2.4 ITERATION STATEMENTS

Semantics

Iteration statements specify that the group of associated statements are executed repeatedly. The FOR statement is used if the number of iterations can be determined in advance; otherwise, the WHILE or REPEAT constructs are used.

- FOR: the FOR statement indicates that a statement sequence is repeatedly executed, up to the END_FOR keyword, while a progression of values is assigned to the FOR loop control variable. The control variable, initial value, and final value are expressions of the same integer type (e.g., SINT, INT, or DINT) and cannot be altered by any of the repeated statements. The FOR statement increments the control variable up or down from an initial value to a final value in increments determined by the value of an expression; this value defaults to 1.The test for the termination condition is made at the beginning of each iteration, so that the statement sequence is not executed if the initial value exceeds the final value.
- WHILE: the WHILE statement causes the sequence of statements up to the END_WHILE keyword to be executed repeatedly until the associated Boolean expression is false. If the expression is initially false, then the group of statements is not executed at all.

- REPEAT: the REPEAT statement causes the sequence of statements up to the UNTIL keyword to be executed repeatedly (and at least once) until the associated Boolean condition is true.
- EXIT: the EXIT statement is used to terminate iterations before the termination condition is satisfied. When the EXIT statement is located within nested iterative constructs, exit is from the innermost loop in which the EXIT is located, that is, control passes to the next statement after the first loop terminator (END_FOR, END_WHILE, or END_REPEAT) following the EXIT statement.

Note: the WHILE and REPEAT statements cannot be used to achieve interprocess synchronization, for example as a "wait loop" with an externally determined termination condition. The SFC elements defined must be used for this purpose.

Syntax

Note that square brackets include optional code, while braces include repeatable portions of code.

1) FOR:

```
FOR control_var := init_val TO end_val [ BY increm_val ] DO
stat_list
END_FOR ;
```

2) WHILE:

```
WHILE expression DO
stat_list
END_WHILE ;
```

3) REPEAT:

```
REPEAT
stat_list
UNTIL expression
END_REPEAT ;
```

Examples

FOR statement:

```
j := 101 ;
FOR i := 1 TO 100 BY 2 DO
 IF arrvals[i] = 57 THEN
j := i ;
 EXIT ;
 END_IF ;
END_FOR ;
```

WHILE statement:

```
j := 1 ;
WHILE j <=100 AND arrvals[i] <>  57 DO
j := j + 2 ;
END_WHILE ;
```

REPEAT statement:

```
j := -1 ;
REPEAT
 j := j + 2 ;
UNTIL j = 101 AND arrvals[i] = 57
```

```
END_REPEAT ;
```

11.6 SEQUENTIAL FUNCTION CHART (SFC)

This section defines Sequential Function Chart (SFC) elements to structure the internal organization of a PLC program organization unit (POU), written in one of the languages defined in this standard, for the purpose of performing sequential control functions. The definitions in this section are derived from IEC 848, with the changes necessary to convert the representations from a documentation standard to a set of execution control elements for a PLC program organization unit.

Since SFC elements require storage of state information, the only program organization units which can be structured using these elements are function blocks and programs.

If any part of a program organization unit is partitioned into SFC elements, the entire program organization unit is so partitioned. If no SFC partitioning is given for a program organization unit, the entire program organization unit is considered to be a single action which executes under the control of the invoking entity.

SFC elements

The SFC elements provide a means of partitioning a PLC program organization unit into a set of steps and transitions interconnected by directed links. Associated with each step is a set of actions, and with each transition is associated a transition condition.

11.6.1 STEPS

11.6.1.1 DEFINITION

A step represents a situation where the behavior of a program organization unit (POU) with respect to its inputs and outputs follows a set of rules defined by the associated actions of the step. A step is either active or inactive. At any given moment, the state of the program organization unit is defined by the set of active steps and the values of its internal and output variables.

A step is represented graphically by a block containing a step name in the form of an identifier. The directed link(s) into the step can be represented graphically by a vertical line attached to the top of the step. The directed link(s) out of the step can be represented by a vertical line attached to the bottom of the step.

Representation	Description
	Step (graphical representation with direct links)

LogicLab does not set any constraint on the maximum number of steps per SFC.

Step flag

The step flag (active or inactive state of a step) can be represented by the logic value of a Boolean variable ***_x, where *** is the step name. This Boolean variable has the value TRUE when the corresponding step is active, and FALSE when it is inactive. The scope of step names and step flags is local to the program organization unit where the steps appear.

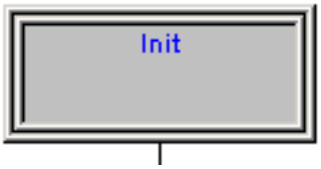
Representation	Description
`Step Name_x`	Step flag = TRUE when `Step Name_x` is active = FALSE otherwise

Users cannot assign a value directly to a step state.

11.6.1.2 INITIAL STEP

The initial state of the program organization unit is represented by the initial values of its internal and output variables, and by its set of initial steps, i.e., the steps which are initially active. Each SFC network, or its textual equivalent, has exactly one initial step. An initial step can be drawn graphically with double lines for the borders, as shown below. For system initialization, the default initial state is FALSE for ordinary steps and TRUE for initial steps.

LogicLab cannot compile an SFC network not containing exactly one initial step.

Representation	Description
	Initial step (graphical representation with direct links)

11.6.1.3 ACTIONS

An action can be:

- a collection of instructions in the IL language;
- a collection of networks in the FBD language;
- a collection of rungs in the LD language;
- a collection of statements in the ST language;
- a sequential function chart (SFC) organized as defined in this section.

Zero or more actions can be associated with each step. Actions are declared via one of the textual structuring elements listed in the following table.

Structuring element	Description

`STEP StepName :`
`(* Step body *)`
`END_STEP`
	Step (textual form)

`INITIAL_STEP StepName :`
`(* Step body *)`
`END_STEP`
	Initial step (textual form)

Such a structuring element exists in the lsc file for every step having at least one associate action.

11.6.1.4 ACTION QUALIFIERS

The time when an action associated to a step is executed depends on its action qualifier. LogicLab implements the following action qualifiers.

Qualifier	Description	Meaning
N	Non-stored (null qualifier).	The action is executed as long as the step remains active.
P	Pulse.	The action is executed only once per step activation, regardless of the number of cycles the step remains active.

If a step has zero associated actions, then it is considered as having a *WAIT* function, that is, waiting for a successor transition condition to become true.

11.6.1.5 JUMPS

Direct links flow only downwards. Therefore, if you want to return to a upper step from a lower one, you cannot draw a logical wire from the latter to the former. A special type of block exists, called Jump, which lets you implement such a transition.

A Jump block is logically equivalent to a step, as they have to always be separated by a transition. The only effect of a Jump is to activate the step flag of the preceding step and to activate the flag of the step it points to.

Representation	Description
	Jump (logical link to the destination step)

11.6.2 TRANSITIONS

11.6.2.1 DEFINITION

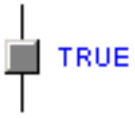
A transition represents the condition whereby control passes from one or more steps preceding the transition to one or more successor steps along the corresponding directed link. The transition is represented by a small grey square across the vertical directed link.

The direction of evolution following the directed links is from the bottom of the predecessor step(s) to the top of the successor step(s).

11.6.2.2 TRANSITION CONDITION

Each transition has an associated transition condition which is the result of the evaluation of a single Boolean expression. A transition condition which is always true is represented by the keyword TRUE, whereas a transition condition always false is symbolized by the keyword FALSE.

A transition condition can be associated with a transition by one of the following means:

Representation	Description
	By placing the appropriate Boolean constant {TRUE, FALSE} adjacent to the vertical directed link.

Representation	Description
	By declaring a Boolean variable, whose value determines whether or not the transition is cleared.
	By writing a piece of code, in any of the languages supported by LogicLab, except for SFC. The result of the evaluation of such a code determines the transition condition.

The scope of a transition name is local to the program organization unit (POU) in which the transition is located.

11.6.3 RULES OF EVOLUTION

Introduction

The initial situation of a SFC network is characterized by the initial step which is in the active state upon initialization of the program or function block containing the network.

Evolutions of the active states of steps take place along the directed links when caused by the clearing of one or more transitions.

A transition is enabled when all the preceding steps, connected to the corresponding transition symbol by directed links, are active. The clearing of a transition occurs when the transition is enabled and when the associated transition condition is true.

The clearing of a transition causes the deactivation (or “resetting”) of all the immediately preceding steps connected to the corresponding transition symbol by directed links, followed by the activation of all the immediately following steps.

The alternation Step/Transition and Transition/Step is always maintained in SFC element connections, that is:

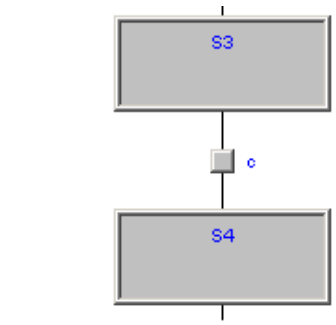
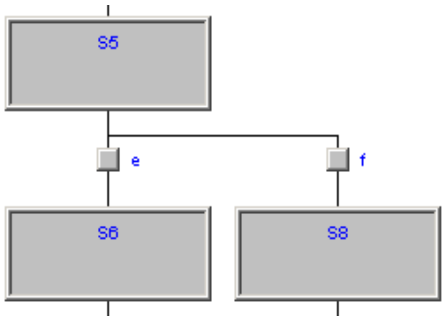
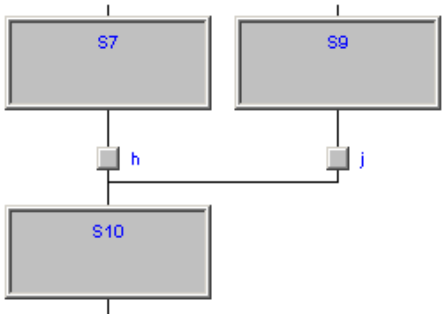
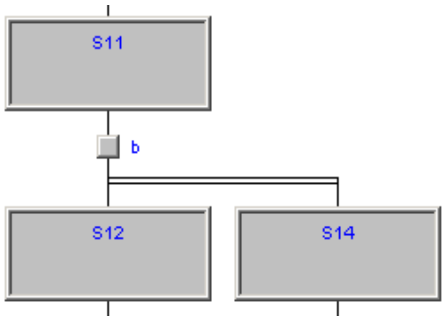
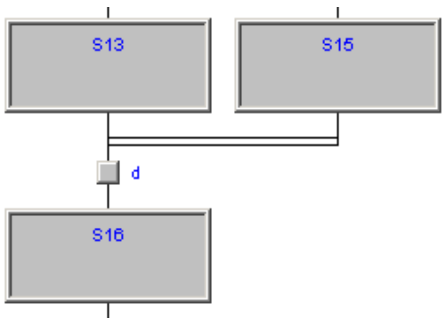
- two steps are never directly linked; they are always separated by a transition;
- two transitions are never directly linked; they are always separated by a step.

When the clearing of a transition leads to the activation of several steps at the same time, the sequences to which these steps belong are called simultaneous sequences. After their simultaneous activation, the evolution of each of these sequences becomes independent. In order to emphasize the special nature of such constructs, the divergence and convergence of simultaneous sequences is indicated by a double horizontal line.

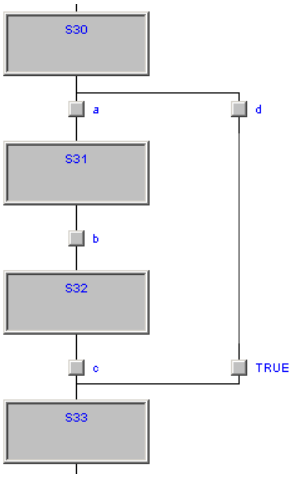
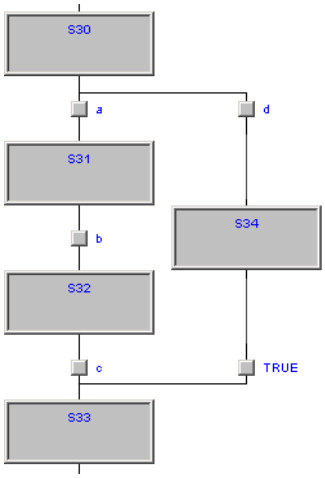
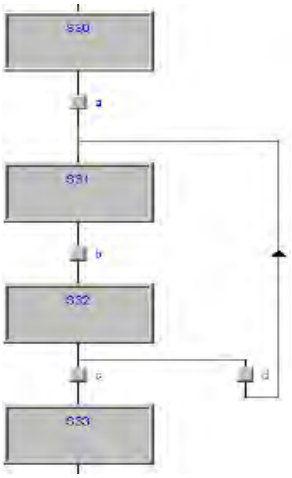
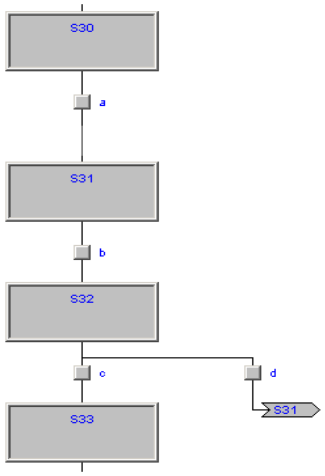
The clearing time of a transition may theoretically be considered as short as one may wish, but it can never be zero. In practice, the clearing time will be imposed by the PLC implementation: several transitions which can be cleared simultaneously will be cleared simultaneously, within the timing constraints of the particular PLC implementation and the priority constraints defined in the sequence evolution table. For the same reason, the duration of a step activity can never be considered to be zero. Testing of the successor transition condition(s) of an active step shall not be performed until the effects of the step activation have propagated throughout the program organization unit in which the step is declared.

Sequence evolution table

This table defines the syntax and semantics of the allowed combinations of steps and transitions.

Example	Rule
	Normal transition An evolution from step S3 to step S4 takes place if and only if step S3 is in the active state and the transition condition c is TRUE.
	Divergent transition An evolution takes place from S5 to S6 if and only if S5 is active and the transition condition e is TRUE, or from S5 to S8 only if S5 is active and f is TRUE and e is FALSE.
	Convergent transition An evolution takes place from S7 to S10 only if S7 is active and the transition condition h is TRUE, or from S9 to S10 only if S9 is active and j is TRUE.
	Simultaneous divergent transition An evolution takes place from S11 to S12, S14,... only if S11 is active and the transition condition b associated to the common transition is TRUE. After the simultaneous activation of S12, S14, etc., the evolution of each sequence proceeds independently.
	Simultaneous convergent transition An evolution takes place from S13, S15,... to S16 only if all steps above and connected to the double horizontal line are active and the transition condition d associated to the common transition is TRUE.

Examples

Invalid scheme	Equivalent allowed scheme	Note
		Expected behavior: an evolution takes place from S30 to S33 if a is FALSE and d is TRUE. The scheme in the leftmost column is invalid because conditions d and TRUE are directly linked.
		Expected behavior: an evolution takes place from S32 to S31 if c is FALSE and d is TRUE. The scheme in the leftmost column is invalid because direct links flow only downwards. Upward transitions can be performed via jump blocks.

11.7 LOGICLAB LANGUAGE EXTENSIONS

LogicLab features a few extensions to the IEC 61131-3 standard, in order to further enrich the language and to adapt to different coding styles.

11.7.1 MACROS

LogicLab implements macros in the same way a C programming language pre-processor does.

Macros can be defined using the following syntax:

```
MACRO <macro name>
PAR_MACRO
      <parameter list>
END_PAR
<macro body>
END_MACRO
```

Note that the parameter list may eventually be empty, thus distinguishing between object-like macros, which do not take parameters, and function-like macros, which do take parameters.

A concrete example of macro definition is the following, which takes two bytes and composes a 16-bit word:

```
MACRO MAKEWORD
    PAR_MACRO
    lobyte;
    hibyte;
    END_PAR
    { CODE:ST }
    lobyte + SHL( TO_UINT( hibyte ), 8 )
END_MACRO
```

Whenever the macro name appears in the source code, it is replaced (along with the actual parameter list, in case of function-like macros) with the macro body. For example, given the definition of the macro MAKEWORD and the following Structured Text code fragment:

```
    w := MAKEWORD( b1, b2 );
```

the macro pre-processor expands it to

```
    w := b1 + SHL( TO_UINT( b2 ), 8 );
```

11.7.2 POINTERS

Pointers are a special kind of variables which act as a reference to another variable (the 1pointed variable). The value of a pointer is, in fact, the address of the pointed variable; in order to access the data stored at the address pointed to, pointers can be dereferenced.

Pointer declaration requires the same syntax used in variable declaration, where the type name is the type name of the pointed variable preceded by a @ sign:

```
    VAR
    <pointer name> : @<pointed variable type name>;
    END_VAR
```

For example, the declaration of a pointer to a REAL variable shall be as follows:

```
    VAR
    px : @REAL;
    END_VAR
```

A pointer can be assigned with another pointer or with an address. A special operator, ADR, is available to retrieve the address of a variable.

```
    px := py;          (* px and py are pointers to REAL (that is, vari-
ables of type @REAL) *)
    px := ADR( x )     (* x is a variable of type REAL *)
    px := ?x           (* ? is an alternative notation for ADR *)
```

The @ operator is used to dereference a pointer, hence to access the pointed variable.

```
    px := ADR( x );
    @px := 3.141592;  (* the approximate value of pi is assigned to x *)
    pn := ADR( n );
    n := @pn + 1;            (* n is incremented by 1 *)
```

Beware that careless use of pointers is potentially dangerous: indeed, pointers can point to any arbitrary location, which can cause undesirable effects.